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A REFERENCE HANDBOOK
OF
THE MEDICAL SCIENCES

EMBRACING THE ENTIRE RANGE OF

SCIENTIFIC AND PRACTICAL MEDICINE
AND
ALLIED SCIENCE

BY VARIOUS WRITERS

A NEW EDITION, COMPLETELY REVISED AND REWRITTEN

EDITED BY ALBERT H. BUCK, M.D.
NEW YORK CITY

ROSWELL P. FLOWER LIBRARY CORNELL UNIVERSITY

VOLUME III.

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A REFERENCE HANDBOOK

OF

THE MEDICAL SCIENCES.

CHLORALAMID.—Introduced in 1889 by Professor von Mering as an hypnotic. It is formed by the combination of one part of formamide, CHO,NH_2, with two parts of chloral anhydride, CCl_3CHO. Its formula is $CCl_3CH,OH,CONH_2$, and would more correctly be named chloral-formamide, or formiate of chloral. The production of this compound is due to the efforts of chemists to introduce into chloral some known stimulant to overcome the depression of the circulation that accompanies the use of chloral. This von Mering thought he had accomplished, as, after absorption, chloralamid is decomposed by the alkalies in the blood into chloral and ammonium formate. The latter exercises a stimulating effect upon the heart and circulation. In addition to this absence of a depressing effect, other advantages over chloral are claimed: It is much less disagreeable in taste, and more soluble, characteristics which render it easy of administration. It is less irritating to the stomach, does not derange the digestive organs, and seldom causes headache, giddiness, or any disturbance of the nervous system.

It occurs in white crystals which have a faintly bitter taste and no odor, and are neutral in reaction. It is soluble in ten parts of cold water and in one and a half parts of alcohol. The salt should never be dissolved in hot water, nor heated above 120° F., as at that temperature it is decomposed. It is also decomposed by alkalies and alkaline carbonates. It is compatible with weak acids, which increase its solubility and render the solution more stable.

Chloralamid has not replaced chloral hydrate nor has it been very generally employed, as its advantages are not very evident. Whether it is less depressant than chloral hydrate or not, is a question that has caused much difference of opinion. Recent researches, however, seem to have shown that the formiate does exert a beneficial effect upon the circulation, especially when administered by the stomach. It is, however, not devoid of depressant action, and when introduced directly into the circulation, as in hypodermic use, it differs very little from chloral hydrate. In considering the differences between the two drugs. the relative proportion of chloral anhydride in each must be kept in mind, 1 part of the anhydride being present in 1.3 part of chloralamid and 1.1 part of chloral hydrate. With many it is thought that this difference in strength really represents the difference in action between the two drugs. It has also been found that chloralamid is less repidly absorbed from the stomach, which renders it more slow and gradual in its action.

Chloralamid is employed as a sedative and hypnotic in all the conditions in which chloral hydrate is indicated; notwithstanding its reputed safety when there is cardiac weakness, it is advisable to employ it in such cases with caution.

The dose advised when the drug was first used was from gr. xx. to xlv., and this has been very generally adhered to. The average dose employed is about gr. xxx. As a rule, it is advisable to begin with a smaller dose of gr. xv. to gr. xx., when the insomnia is not accompanied by pain or excitement. On account of its solubility in alcohol, chloralamid is easily given in solution diluted with some aromatic elixir. Brandy or whiskey is a favorite means and adds to its beneficial action. If alcoholic solution is not desired, dilute hydrochloric acid will be found to serve the purpose. It may also be given in cachets. For whooping-cough and other spasmodic affections, it is given in doses of gr. ij. every two hours. Enemata may also be employed when such a means of administering the drug is desired. The following formula is recommended for this purpose: chloralamid, gr. xiv.; dilute hydrochloric acid, gtt. iij.; alcohol, gtt. xx.; water, ʒ iij. *Beaumont Small.*

CHLORALIMID.—(Trichlor-ethyliden-imide), CCl_3, CH-NH. This substance is obtained by the action of acetate of ammonia on chloral hydrate; it may also be formed by heating chloral ammonia. It is a crystalline acidular powder without taste, smell, or color, insoluble in water, soluble in alcohol, ether, and oils. It is not affected by heat or moisture. It possesses properties similar to those belonging to chloralamid, but is more active. As an hypnotic, it is given in doses of from gr. v. to xxx. It is introduced as a substitute for chloral hydrate and chloralamid. It has not the acrid taste of the former nor the bitter taste of the latter. In smaller doses it is said to have an antipyretic and analgesic action. This drug has not been used to any extent, and its superiority to chloralamid has yet to be determined. *Beaumont Small.*

CHLORATES. See *Potassium* and *Sodium.*

CHLORATES, POISONING BY.—When we speak of poisoning by chlorates we have in mind chiefly the poisoning by chlorate of potassium, of which there are already a goodly number of cases on record. It is, however, generally conceded that the poisoning is mainly due to the chlorate ion of this salt. We can also readily cause poisoning by the sodium chlorate, and it is even claimed that the ammonium salt is the most poisonous of all the chlorates. The greater frequency of poisoning by the potassium salt is due to its frequent use. On the erroneous supposition that the readily oxidizing potassium chlorate will give up oxygen to the tissues and fluids of the animal body, this salt was extensively employed throughout the entire nineteenth century as a therapeutic agent for all sorts of diseases (von Mering [1]).

It is, however, a noteworthy fact that, with a few exceptions, the record of poisoning by chlorate of potassium is practically not much older than the last two decades, *i.e.*, since the danger of this therapeutic agent was impressively brought to the minds of the medical profession by the writings of A. Jacobi [2] and F. Marchand [3] at the end of the seventies.

The first case on record is apparently that which occurred in Tulle, France, and which was described by Chevalier [4] in 1855. A man took 20 gm. of the salt for two days and died manifesting violent symptoms. This case attracted considerable attention, and was apparently the incentive for the toxicological studies of potassium chlorate which began in France earlier than in other countries.[5]

There is one other case that deserves especial mention. It is the tragic death of Dr. Fountain, of Davenport, Iowa. This physician, a great admirer of potassium chlorate, read a paper in 1859 at the meeting of the American Medical Association, enthusiastically recommending this salt in the treatment of pulmonary tuberculosis.[6] This paper called forth considerable discussion and not a little adverse criticism. As an answer to the statement of Osborne[7] that even fifteen grains of this drug sometimes cause serious symptoms, Fountain took repeatedly half-ounce doses without harmful effects. In 1860 Dr. Elsberg, of New York, prescribed potassium chlorate as a gargle. The patient took it internally (about 20 gm. daily) and died after four days. A coroner's jury of physicians gave the verdict that death was due to poisoning by potassium chlorate.[8] Incensed by this verdict and to prove the innocuousness of this salt, Fountain took on the 22d of March, 1861, an ounce of it in a single dose—and died on the 29th of the same month under complete anuria.[9]

The poisoning cases on record were brought about mostly by taking a large dose of the salt either to commit suicide or to induce criminal abortion; or it was taken by mistake instead of a cathartic salt, or the directions of the physician were misunderstood and it was taken internally instead of being used as a gargle. There is no doubt, however, that a good many cases of poisoning, and more than were reported, occurred when the salt was taken internally for therapeutic purposes; and a few, it seems, even when it was used as a gargle. But the symptoms of the poisoning resembled so much the symptoms of the disease for which the salt was taken—diphtheria, for instance—that the fatal outcome was often enough attributed to the disease rather than to the drug.

The clinical symptoms which attracted attention in the earliest observations were those pertaining to the gastro-intestinal tract. Later on, dysuric symptoms were recognized, and many writers spoke of hemorrhagic nephritis. In the last quarter of the century, however, the attention of writers, especially of experimental investigators, was attracted by the peculiar changes in the blood. Indeed, it had been early observed that extravascular blood becomes bright red when mixed with potassium chlorate, and this was taken as a sign of the oxygenation of the blood by the salt. The increased brightness, however, is due not to "arterialization" but to the greater reflexion of light on account of the diminished transparency of the chloratized blood. Moreover, the bright color very soon gives way to a chocolate or sepia color which was first observed by Isambert[10] in the extravascular blood as well as in the blood of animals poisoned by chlorate of potassium. Jäderholm[11] was the first to recognize that the dark color was due to the formation of methæmoglobin in the blood. This subject has been extensively studied by Marchand[12] and by many subsequent investigators.[13]

Methæmoglobin is neither an oxidation nor a reduction product of oxyhæmoglobin, as has been assumed, but is rather isomeric with it. Methæmoglobin, however, does not give up its oxygen as readily as oxyhæmoglobin. Methæmoglobin is recognized by an absorption band at the red end of the spectrum between C and D. Carbonic acid, higher temperature, and diminished alkalinity of the blood favor its formation. Potassium chlorate at first causes the formation of methæmoglobin within the red cells, but the latter is subsequently dissolved into the serum.

Besides its influence upon the hæmoglobin, potassium chlorate exerts also in some other respects a deleterious effect upon the red blood cells. They shrink, break down into small fragments, and conglutinate into large gelatinous masses. In bullock's blood I found that all the red blood corpuscles became smaller and more refractile, and lost their biconcavity. In such blood which I kept for over eight years, the cells never changed their shape and proved to be at all times considerably resistant to all chemical and mechanical manipulations. In my experiments blood mixed with potassium chlorate remained free from putrefaction for a considerable length of time. In experiments of Welch and myself,[14] in which it was established that a certain degree of shaking caused a molecular destruction of the red blood cells, we found that the addition of potassium chlorate made the red cells resistant to any kind of shaking.

The blood of different animals differs considerably in its sensitiveness to the influence of potassium chlorate. It is stated that the blood of the cat is eleven times more sensitive than that of the dog; human blood seems to be equal in its sensitiveness to that of the dog. The blood of rabbits and guinea-pigs poisoned by potassium chlorate shows neither during life nor soon after death the formation of methæmoglobin or destruction of the red cells. However, sixteen or twenty hours after death the blood of these animals, too, assumes a chocolate color and contains methæmoglobin. According to Falck,[15] by injections of concentrated sodium chlorate, serum globulin, bile, etc., the blood of these animals also responds to the poisoning by potassium chlorate with an intravital formation of methæmoglobin.

The prevailing view as to the main causes of poisoning by potassium chlorate presents itself as follows: In acute poisoning the hæmoglobin of a very large number of red blood corpuscles becomes converted into methæmoglobin which does not give up its oxygen to the tissues, and asphyxia is then practically the cause of death. In less acute cases, when there still remains a number of normal red blood cells sufficiently large to carry on an indispensable minimum of respiratory changes, the animal might survive this primary attack and the methæmoglobin might even gradually re-form into normal hæmoglobin. But then the secondary effect of the destruction of the red cells comes into play. The débris of the broken-down corpuscles plugs up the renal tubules, causing all forms of dysuria. In these subacute cases death is caused by uræmia. Outside of these main causes of death, charged to the account of the chlorate ion of this salt, it is assumed that the "salt action" might also play a contributory rôle in the fatal issue, *i.e.*, potassium chlorate causes, like all salts, irritation and inflammation of the gastro-intestinal canal, the kidney epithelium, etc. In poisoning with potassium salt, the depressing effect of potassium upon the heart might also come into consideration.

As to the process by which potassium chlorate causes the changes of the blood within the living animal, we have no definite knowledge. Against the supposition that the change is effected by the oxidizing property of the drug, seems to be the fact, as was shown by Isambert,[16] Rabuteau,[17] and von Mering,[18] that nearly the entire quantity of the administered potassium chlorate very soon reappears in the urine entirely unchanged. However, even very minute reductions of the chlorate salt are sufficient to bring about the changes in the hæmoglobin, as is indeed surmised by von Mering. Furthermore, there is no proof nor even any good reason against an assumption that potassium salt is indeed reduced within the blood but becomes reoxidized again while leaving the body.

Regarding the quantity, it is generally stated that from 15 to 20 gm. in a single dose are fatal. We have seen above that 30 gm. killed Dr. Fountain. In a series of well-conducted experiments by Professor Tully, of Yale College, as early as 1832,[19] we find, however, that he as well as his students had several times taken one ounce of this salt in single dose without serious aftereffects. And Percy[20] is authority for the statement that in 1858 A. Jacobi had taken two ounces in two days without any more serious effects than nausea, slight diarrhœa, and increased diuresis. It seems that in the early part of the century 10 to 46 gm. used to be the therapeutic dose given internally within twenty-four hours (Herpin[21]). There are, however, cases on record in which 10 gm. have killed an adult, and 4 gm. given in the course of one night have killed an infant one year old. The effect seems to depend upon the condition of the stomach; on an empty stomach the drug is more poisonous (Tacke,[22] von Mering[23]). The condition of the kidneys is also an influential factor, as a pathological state of the kidneys prevents the secretion of the salt and thereby favors its accumulation within the blood (Lewin and Posner[24]). Fever, dyspnœa, and other diseased conditions of the body also facilitate the poisonous effect of the salts (von Mering). In animals the poisoning is accomplished not only by administration by the mouth, but also and in a more marked degree by subcutaneous, intraperitoneal, or intravenous injections of the drug.

Symptoms and Course.—The poisoning has either an acute or a subacute course, according to the quantity of the chlorate salt administered. When a single large dose is taken the symptoms of poisoning set in quite soon and life is terminated within a few hours. The symptoms are violent and incessant: vomiting, the dark vomitus containing mostly bile, rarely blood; diarrhœa, sometimes bloody; intestinal and at times also vesical tenesmus; severe pain in the abdomen, thirst, great prostration, and dyspnœa. Sometimes convulsions, sometimes coma closes the scene. The mucous membranes, the skin under the nails, and sometimes also other parts of the skin show peculiar cyanotic discolorations. The blood is of a chocolate color and contains methæmoglobin. In other cases, especially when smaller but repeated doses are employed, the onset may be quite insidious and the poisoning runs a protracted course with a fatal termination on the eighth or tenth day. In these cases, too, gastro-intestinal symptoms prevail, but are less violent and usually subside after a day or two. Here, however, the urinary disturbance is the predominant feature. After a short period of increased diuresis the urine becomes more and more scanty until complete anuria sets in, which lasts sometimes for many days, until death closes the scene. The urine is albuminous, is of a dark reddish or chocolate color, contains débris of red blood corpuscles, some "shadows," and casts of reddish-brown particles. It contains also, at least at the beginning, potassium chlorate, methæmoglobin, and hæmatin. The skin is of an extreme pallor and icteric, sometimes has copper-colored spots and multiform exudative erythema. The spleen and liver are enlarged. The blood contains débris of red cells which are greatly reduced in number; the white cells are increased at the beginning,[25 26] but they also decrease toward the end; methæmoglobin is present only at the beginning of the poisoning. Of the subjective symptoms are to be mentioned: headache, pains in the abdominal and lumbar regions, insomnia, great distress, dyspnœa, etc. The multiform manifestations of uræmia are usually the features dominating the closing scenes.

Autopsy.—In acute cases the sepia color of the blood and many organs and the presence of methæmoglobin are the characteristic features. In subacute cases the characteristic color is rarely present; but here we find depositions of broken-down red blood corpuscles in the bone marrow, spleen, and liver; the latter two organs are enlarged. The kidneys, too, are usually swollen, the tubules are filled up with the débris of the red blood cells, the epithelia are in a state of cloudy swelling, which is, however, according to Marchand, of a secondary nature and due only to the pressure of the plugs. Thrombi were not found in any part of the body. The mucous membrane of the gastro-intestinal canal is often found to be swollen and ecchymotic.

The *Prognosis* in well-developed cases of poisoning is quite bad. The mortality of seventy per cent., which is given by some authors, is too low, as the statistics include also quite mild cases. There is, however, no doubt that recovery can yet take place even in quite desperate cases. At the same time it should be borne in mind that in many cases of fatal poisoning a temporary rallying occurs which deceives both doctor and family.

In the preceding sketch I have followed closely the lines laid down by all recent writers on the subject of poisoning by potassium chlorate. I wish to add, however, that to my mind the view as it is stated here, and as it has been in undisputed vogue for the last dozen years—namely, that the changes in the blood are the sole cause of the poisoning symptoms and fatal outcome—is not entirely correct. I have seen animals die in half an hour after intraperitoneal injection of potassium chlorate, without any changes in the blood or the kidneys. Of what did these animals die? There are in the literature cases of poisoning by potassium chlorate in which clonic convulsions occurred before any signs of a disturbance of the kidney were present, and therefore without any cause for uræmia. What caused the convulsions? Results which I have obtained in a series of experiments[27] might offer an explanation of these and other symptoms. By injecting gtt. iij. to v. of a five-per-cent. solution of potassium chlorate into the brain of rabbits, the animals pass through a series of violent tonic and clonic convulsions which end in a paralytic and comatose state. A ten-per-cent. solution of sodium chloride does not have such an effect. This shows that potassium chlorate is a poison for the nerve cells, first exciting then paralyzing them. May it not also be that by introducing the potassium chlorate into the body by any other method, some of the poison finds its way into the brain and exerts there exciting and paralyzing effects?

Treatment.—As prophylactic measures it may be suggested that the sale of potassium chlorate should be restricted. Large doses or prolonged administration of the drug should be avoided. It should be taken on a full stomach. When prescribed as a gargle it should be marked "Poison." Potassium chlorate is excreted by the milk glands and should therefore be avoided by nursing mothers. When poisonous symptoms set in, thorough washing of the stomach and bowels should be practised first, to be followed up by the administration of an ounce of castor oil. Small doses of cocaine and morphine, an ice-bag on the epigastrium, and other measures appropriate to control vomiting, pain, etc., should be instituted. Drinking of water and alkaline solutions to stimulate diuresis, etc., should be encouraged, but acidulous drinks and lemonades should be avoided. Cardiac stimulants, to be administered hypodermically, are indicated; caffeine and sodium benzoate, which are both stimulant and diuretic, are especially serviceable. Oxygen might do some good. Venesection, followed by transfusion of an alkaline saline, might relieve the blood from the deleterious waste products and at the same time stimulate diuresis. Cautious use of pilocarpine to stimulate perspiration and salivation is recommended. Hot baths too will increase perspiration and relieve the blood and kidneys.

S. J. Meltzer.

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CHLORIDES.—The chlorides used in medicine are: among the chlorides of the heavy metals, those, severally, of iron, mercury, gold and sodium, and zinc; among the chlorides of the alkalies, those, severally, of sodium, ammonium, and calcium; and among the chlorides of the alkaline earths, the chloride of barium. With the single exception of mercurous chloride (calomel), the chlorides of the heavy metals are distinguished among their sister salts for comparatively free solubility and great intensity of action. The iron, gold, and zinc chlorides are, furthermore, deliquescent to a high degree. For detailed discussion of the metallic chlorides, see articles under title of the several metals, and for barium chloride, see under *Barium.* In the case of the chlorides of the alkali bases, the influence over nutrition which they derive from their chlorine element exceeds in medicinal importance what properties are due to the basic radicle. The chlorides of the alkalies, therefore, may properly be regarded as constituting a distinct group of medicines.

Sodium Chloride: $NaCl$.—Sodium chloride, well known as *common salt, table salt, sea salt,* or simply *salt,* is official in the United States Pharmacopœia as *Sodii Chloridum,* Sodium Chloride. It occurs as "colorless, transparent, cubical crystals, or a white, crystalline powder, odorless, and having a purely saline taste. Permanent in dry air. Soluble in 2.8 parts of water at 15° C. (59° F.), and in 2.5 parts of boiling water; almost insoluble in alcohol; insoluble in ether or chloroform. When heated, the salt decrepitates; at a red heat it fuses, and at a white heat it is slowly volatilized and partly decomposed. To a non-luminous flame it imparts an intense, yellow color. The aqueous solution of the salt is neutral to litmus paper" (U. S. P.). While, as described, perfectly pure sodium chloride is permanent in the air, commercial table salt, containing, as it does, variable proportions of magnesium chloride, is more or less hygroscopic, becoming damp on exposure to moist air. Salt is the principal saline ingredient of sea water, and occurs native, also, in enormous quantities as a mineral. It is obtained for commerce from salt mines, and also, to a certain extent, by evaporating the water of the sea and of saline springs.

Sodium chloride is an important normal constituent of the body fluids, and accordingly is perfectly harmless to swallow in any ordinary quantity. The only effects following its special administration are, in moderate dosage, an improvement of appetite and digestion, and probably also a quickening of assimilation and nutrition. In large single doses salt is decidedly emetic, especially if taken in a lukewarm draught. Therapeutically, it is in the first place important to remember the absolute necessity of salt in the dietary, and so to see to it that dishes for the sick-room are not made too insipid by lack of salt. Next, salt is a fairly serviceable emetic; but not sufficiently powerful for urgent requirements. Accordingly, it is used rather as an adjuvant to more active emetics, than as itself a vomiting agent. Another application of salt is its administration, dry, in quantity of a teaspoonful or so, in hemorrhage of the lungs, over which affection salt is supposed to have some control; but such use, although unobjectionable, should not be to the exclusion of more potent remedies. In the matter of external application, it is notorious that salt water is more stimulating to the skin than fresh, and that, for the purpose of the constitutional reaction to be obtained, salt baths are more serviceable than fresh, and are borne by weaklings with less danger of giving "cold." The dose of salt as an appetizer is about 0.65 gm. (gr. x.), but the dosage is obviously very indeterminable, and much may be left to individual peculiarities of taste. As an auxiliary emetic, 15–30 gm. (℥ ss.–i.) should be given in a tumblerful of lukewarm water. For saline baths sea water is best, but when not available a good substitute is afforded by a three-per-cent. aqueous solution of common table salt (a pound to four gallons). For the bathing of sensitive mucous membranes, such as the conjunctiva or the Schneiderian mucous membrane in its upper portion, a weak solution of common salt affords a fluid far less painful than simple water, for the reason that such solution approaches more nearly the normal specific gravity of the fluids of the part. Such solution should range between one-half and one per cent. in strength, but it is near enough for practical purposes to make the solution by adding to a couple of fluidounces of water as much salt as will lie on the thumb nail. For injection into the nasal cavity, the solution should be blood-warm.

Ammonium Chloride: NH_4Cl.—This salt, commercially known as *sal ammoniac,* and still often called by the old-fashioned chemical name *muriate of ammonia,* is official in the United States Pharmacopœia only in a purified condition, under the title *Ammonii Chloridum,* Ammonium Chloride. Commercial sal ammoniac is now most commonly obtained from an ammoniacal liquor that occurs as a by-product in the making of illuminating gas, and is in the form of fibrous crystalline cakes of a peculiarly tough texture, making the substance very difficult to pulverize. In this condition the salt is contaminated with chloride of iron, and has to undergo a purification therefrom to fit it for medicinal use. The purified sal ammoniac is thus obtained granulated, and presents itself as "a white, crystalline powder, without odor, having a cooling, saline taste, and permanent in the air. Soluble in three parts of water at 15° C. (59° F.), and in one part of boiling water, but almost insoluble in alcohol. On ignition the salt is completely volatilized, without charring" (U. S. P.).

Physiologically, ammonium chloride seems to combine to a certain extent the peculiar virtues of ammonia (see *Ammonia*) with those of the chlorides. In continuous full dosage it deranges the stomach and bowels, exciting vomiting and purging. Its medicinal applications have been very varied, but those which have best stood the test of well-observed experience are the use of the salt to relieve myalgia and some neuralgias, and to promote free expectoration in bronchial catarrhs in the second stage, especially in cases in which the secretion is thick, tenacious, and difficult to dislodge. By German practitioners the salt is much employed also in inflammatory affections, generally where there is some product of the inflammation whose reabsorption is desirable. The average dose of ammonium chloride is from 0.30 to 0.65 gm. (gr. v.–x.) every two or three hours. It is generally given in solution, as an ingredient of composite prescriptions, and, since its taste is very disagreeable, it is well to have a little licorice added to the mixture to disguise the flavor. *Troches of ammonium chloride* are official, each containing 0.10 gm. (gr. iss.) of the salt. Externally applied, sal ammoniac in solution is a gentle irritant, and an aqueous solution, from one to three per cent. in strength, may be used as a lotion to sluggish ulcers, etc., requiring a mildly irritant impression. A local application in respiratory catarrhs has also been devised whereby the patient inhales the salt, formed in a fine cloud in air, by an arrangement that brings together the vapors of hydrochloric acid and water of ammonia. Lastly, ammonium chloride furnishes a possible means of applying cold, since by solution in water it reduces the temperature thereof quite decidedly. Thirty-five parts each of ammonium chloride and potassium nitrate to one hundred of water will lower the temperature from ten to fifteen degrees of the Fahrenheit scale. In the absence of ice such a mixture may be put into a rubber bag and applied for purposes of refrigeration during the time that the salts are in process of dissolving.

Calcium Chloride: $CaCl_2$.—Calcium chloride, "rendered anhydrous by fusion at the lowest possible temperature," is official as *Calcii Chloridum,* Calcium Chloride. Such fused salt occurs in "white, slightly translucent, hard fragments, odorless, having a sharp, saline taste, and very deliquescent. Soluble at 15° C. (59° F)., in 1.5 parts of water, and in 8 parts of alcohol; in 1.5 parts of boiling alcohol, and very freely in boiling water; insoluble in ether. Below a red heat the salt fuses" (U. S. P.). Calcium chloride, because of its extreme deliquescence, must be kept in well-stoppered bottles.

This salt presents a combination of an acid and a basylous radicle, both of which are peculiarly effective in the determining of sound nutrition. Accordingly a course of calcium chloride has been found beneficial in cases of indurated and enlarged glands, or of a manifest scrofulous cachexia, or of tabes mesenterica. In large dose the salt is a dangerous irritant. The therapeutic dose is from 0.65 to 1.30 gm. (gr. x.–xx.) taken preferably dissolved in a wineglassful of *milk* (Coghill: *The Practitioner*, vol. xix., p. 251) and after eating. *Edward Curtis.*

CHLORINE.—Chlorine is a greenish-yellow gas, soluble in water, possessed of a peculiar and disagreeable odor, and an intensely irritant action upon animal tissues. Even in the comparatively weak dilution of one per cent. in air chlorine excites violent spasm of the larynx, and if actually inhaled leads to irritation and inflammation of the air passages, accompanied, perhaps, by hemorrhages, and possibly followed by death. Habit, however, establishes considerable tolerance, so that workmen in bleacheries get to breathe without distress a chlorinated atmosphere impossible of respiration to one unaccustomed. Feebly chlorinated air excites only a glow of warmth in the air passages, and an increase of bronchial mucus. Taken internally, in the form of strong chlorinated solutions, chlorine is powerfully irritant and even corrosive. In poisoning by inhalation of chlorine, the sufferer should be made to breathe cautiously the fumes of ammonia, or a weak mixture of sulphureted hydrogen in air. In poisoning by swallowing, albumen should be given freely, and the lesions treated upon general medical principles.

Chlorine is valuable to the physician because of a consequence of the strong affinity of the element for hydrogen, with which body chlorine unites to form hydrochloric acid. By virtue of this affinity chlorine can decompose water, especially in the light, appropriating the hydrogen and setting free the oxygen. Such nascent oxygen is then active for oxidizing, and will attack and decompose by oxidation any organic matter that may happen to be within reach. Vegetable coloring matters and noisome products of putrefactive or fermentative processes fall particularly easy prey to active oxygen, and as a result of their oxidation the color of the one group and the smell of the other undergo complete abrogation. In a roundabout way, therefore, chlorine, in the presence of moisture, is a powerful bleacher of organic dyes and a deodorizer of organic foulness. Reasoning from the easily obtained deodorant action of chlorine, it is naturally hoped that the element may also, under the conditions that currently present themselves, oxidize and so disinfect the organic matter of particulate carriers or generators of contagium—disease germs, commonly so called. But while there is no doubt of the power of chlorine so to do, if in sufficient concentration and in the presence of moisture, yet clinical experience and exact experiments combine to prove that to disinfect a room occupied by one ill of a contagious disease, the chlorination of the air must be carried beyond the limit of respirability, and to a degree which will also determine the bleaching, more or less, of colored fabrics. Sternberg, experimenting with vaccine points, found that to destroy their potency by exposure to chlorine-charged air, a charge per volume of one-half of one per cent., perfectly maintained, was necessary, and an exposure to such atmosphere of six hours' duration.[1] Considering, however, the conditions presented by a sick-chamber, where tight closure of the room is difficult to effect and where the germs easily fall into places comparatively inaccessible, a percentage at least double the above—that is, one per cent.—should be regarded as the minimum of probable efficiency.

The therapeutic application of gaseous chlorine is to deodorize, disinfect, or both. For purposes of deodorizing simply, chlorinated lime or chlorinated soda are fairly efficient, but for aërial disinfection chlorine gas must be generated in greater volume than can conveniently be gotten from those preparations. At best, however, chlorine is inferior for this purpose to sulphur dioxide, since the latter is probably more efficient as a disinfectant, while less obnoxious to carpets and clothing. For a reasonably reliable effect, chlorine gas should be evolved in great excess of estimated minimum percentages, with the room as perfectly closed as possible, and with all articles to be disinfected as freely exposed on all sides to the atmosphere as may be. Much more commonly, however, chlorine has been used on the small scale in sick-chambers while still inhabited by the patient—a procedure which, from the point of view of genuine disinfection, is not merely futile, but leads to the positive danger of the omission of other and really potent disinfectant measures. Gaseous chlorine is most conveniently generated in considerable volume by Wiggers' method, as follows: "Mix 18 parts of finely ground common salt with 15 parts of *finely pulverized* good binoxide of manganese; put the mixture into a flask, and pour a *completely cooled* mixture of 45 parts of concentrated sulphuric acid and 21 parts of water upon it, and shake the flask; a uniform and continuous evolution of chlorine gas will soon begin, which, when slackening, may be easily increased again by *gentle* heat" (Fresenius). According to Squibb,[2] "about two hundred grains of the common salt mixture, and half a fluidounce of the sulphuric acid mixture, liberates in the course of twelve or twenty-four hours about fifty cubic inches of chlorine, giving it off pretty rapidly for the first two or three hours, and very slowly afterward." Estimating from these data, a cubic foot of chlorine requires for its yield about a pound and a quarter of the salt mixture, and a little over a pint of the acid; and, therefore, for a one-per-cent. chlorination, by volume, of the air of the average bedroom of about two thousand cubic feet capacity, twenty-five pounds of the salt mixture and about eleven quarts of the dilute acid would have to be used! And when it is remembered that the one-per-cent. impregnation thus obtained is probably the minimum of efficiency, comment is unnecessary on the common practice of setting a saucer or two, holding each a half-ounce of the salt mixture, under the sick-bed with a serious view to disinfection. All that such procedure can possibly accomplish is a slight *deodorizing*.

Locally, chlorine, applied in the form of chlorinated substances and solutions, operates as a disinfectant, detergent, and deodorant, and, by virtue of its irritant properties, also as a stimulant to healthy action in wounds and sores. The United States Pharmacopœial preparations of chlorine, available for the purposes thus suggested, are the following:

Aqua Chlori, Chlorine Water.—"An aqueous solution of chlorine, containing at least 0.4 per cent. of the gas" (U. S. P.). Chlorine gas, generated by the action of diluted hydrochloric acid upon black oxide of manganese, is conducted into a bottle of distilled water until the latter, after agitation, is saturated with the gas in solution. The product, from its extreme proneness to spontaneous change, must be put up in "dark, amber-colored, glass-stoppered bottles," and these completely filled and kept in a dark and cool place. Chlorine water, when freshly made, is a "clear, greenish-yellow liquid, having the suffocating odor and disagreeable taste of chlorine, and leaving no residue on evaporation. It instantly decolorizes dilute solutions of litmus, indigo, and other vegetable coloring matters" (U. S. P.). Chlorine water, especially on exposure to light, tends to lose strength by reason of the chlorine decomposing the water, and uniting with the hydrogen thereof to form hydrochloric acid; when wanted of full strength, therefore, the preparation should be freshly made.

Chlorine water is used in medicine mainly as a local application, either as a lotion for foul or indolent ulcerated surfaces upon the skin, or as a gargle in analogous conditions of the mucous membrane of the throat. If freshly made it is intolerably pungent of chlorine, and should be diluted severalfold with water for use. Internally the remedy is occasionally given, generally in the so-called zymotic diseases, in the hope probably of a constitutional antiseptic action—a hope little likely to be fulfilled. From half a teaspoonful to a teaspoonful may be given at a dose, diluted with five or six volumes of water. Nothing organic should be added to the potion, such as syrup or glycerin, else the free chlorine will rapidly disappear as such. The dose is very disagreeable to take.

Calx Chlorata, Chlorinated Lime.—This is the preparation, commonly miscalled *chloride of lime*, which results from exposing calcium hydroxide (slaked lime) to chlorine gas. The lime absorbs the chlorine with the formation of a peculiar product, which by the standard of the United States Pharmacopœia should contain "not less than thirty-five per cent. of available chlorine." Chlorinated lime is in the form of "a white, or grayish-white, granular powder, exhaling the odor of hypochlorous acid, having a repulsive, saline taste, and becoming moist and gradually decomposing on exposure to air. In water or in alcohol it is only partially soluble. The aqueous solution first colors red litmus paper blue, and then bleaches it. If the salt be dissolved in diluted acetic acid, an abundance of chlorine gas is evolved, and only a trifling residue left undissolved" (U. S. P.). Chlorinated lime undergoes spontaneous change on exposure to air, and accordingly must be kept in well-closed vessels in a cool and dry place. If put up in glass-stoppered bottles, the stoppers must be guarded by a thin smear of paraffin, else they will become irremovably fixed to their seats.

The composition of chlorinated lime has proved a difficult matter to determine definitely. It has been supposed to be represented by a mixture of calcium chloride and calcium hypochlorite ($CaCl_2 + CaCl_2O_2$), but certain chemical considerations make it likely that the true composition is according to Odling's formula, viz., $CaCl,OCl$. The important chemical reaction upon which the medical virtues of the compound rest is the ready decomposition of chlorinated lime by any acid, however weak—even carbonic acid—with the evolution of free chlorine. Hence, by mere exposure to the atmosphere, the preparation continuously disengages chlorine through attack by the carbon dioxide ever present in the air, and, if treated with an acid of any power, such as hydrochloric, nitric, acetic, etc., the yield of chlorine is prompt and decided. Medicinally, partly through its evolving free chlorine and partly by virtue of its properties while under its own form, chlorinated lime is alkaline, desiccant, irritant, deodorant, and disinfectant. It is also cheap, and so combines many qualities that make it of genuine value. Its most common employment is as a disinfectant; in which capacity for aërial disinfection its yield of chlorine is insufficient, but for direct application to solid or fluid infectious material, or for the cleansing of contaminated articles, it is excellent. Its only drawbacks are its chlorinous odor, its powerful bleaching action, and the fact that it attacks metals. As a deodorant it is very potent, operating in this service even aërially upon the foul gases, but being, of course, more efficacious if directly applied to the noisome thing itself. For use as a disinfectant or deodorant, chlorinated lime may be thrown, in bulk, and liberally, down privies, drains, or sinks, or into chamber vessels (of china or glass) before use; or strewn, before scrubbing, upon foul floors; or in solution, from one to three or four per cent. in water, used as a detergent lotion upon corpses, sloughing wounds, or strong-smelling feet or armpits, etc. In these various applications the preparation must not be applied strong to colored or delicate fabrics, lest the color be discharged and the texture injured. Apart from its mere deodorant property, chlorinated lime is serviceable in promoting healthy action in sluggish and foul sores, skin eruptions, etc. For this purpose a one-per-cent. lotion is a convenient form of application. Internally, chlorinated lime has been given as a source of chlorine, aimed to combat the morbific principle in zymotic disease. It may be given in sweetened solution, freshly mixed and in doses of from .06 to .40 gm. (gr. i. to vi.). A last and special application is the inhalation of the fumes of chlorinated lime in cases of poisoning by breathing sulphureted hydrogen, as may occur to workmen entering sewers. The gas is always immediately decomposed by the chlorine of the lime compound.

Liquor Sodæ Chloratæ, Solution of Chlorinated Soda; Labarraque's Solution.—This preparation is made by pouring a boiling-hot aqueous solution of sodium carbonate into a filtered aqueous solution of chlorinated lime. The sodium and calcium change places, calcium carbonate being precipitated, and a chlorinated compound of sodium analogous in composition to the pre-existing calcic compound, remaining in solution. But the sodium carbonate being ordered in excess, some of this salt, unchanged, remains in the preparation. The mixture, after filtration, is brought to standard strength by the addition of water. The product must be kept, protected from the light, in well-stoppered bottles, and if these be glass-stoppered, the stoppers should be overlaid with a thin smear of melted paraffin, else they will become irremovably fixed in their seats. Solution of chlorinated soda should contain "at least 2.6 per cent., by weight, of available chlorine." The preparation is "a clear, pale, greenish liquid, having a faint odor of chlorine, and a disagreeable, alkaline taste. Specific gravity about 1.052 at 15° C. (59° F.). The solution at first colors red litmus paper blue, and then bleaches it. The addition of hydrochloric acid to the solution causes an effervescence of chlorine and carbonic acid gas" (U. S. P.).

Chlorinated soda has, intrinsically, similar properties to chlorinated lime, and, like the latter compound, is readily decomposed by acids with the evolution of free chlorine. Its therapeutic uses are therefore the same as those of the lime compound. The solution may be used as a deodorant disinfectant, poured down drains, sinks, or into chamber vessels of crockery or glass, or, diluted from five to tenfold, employed as a detergent and gently irritant lotion to foul ulcers, skin eruptions, etc. Like chlorinated lime, this solution has been given internally in zymotic diseases, the dose being from one-half to one teaspoonful, diluted manifold with water, and repeated every two or three hours. *Edward Curtis.*

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[1] Sternberg: National [U. S.] Board of Health Bulletin, vol. iii., p. 21.

[2] Squibb: Disinfectants. The Medical Record, May 1st and 15th, 1866.

CHLOROBROM is the registered trade name of a combination of chloralamid and bromide of potassium. This combination, which possesses the active properties of both its constituents, has been recommended by Professor Charteris, of Glasgow, as a remedy for sea-sickness. He had used it in many cases with very gratifying results. A dose is given after the stomach has been emptied of its contents; the sense of depression is relieved and nausea checked; a quiet sleep follows, from which the patient awakes relieved of all the distressing symptoms. The remedy may be prepared as follows: Chloralamid, bromide of potassium, of each ʒ iss.; water, ℥ ij.; syrup, ℥ i. One to one and a half tablespoonfuls for a dose.

Beaumont Small.

CHLORODYNE.—Chlorodine. This title has been arbitrarily applied to mixtures differing considerably in composition, none of them official in the United States Pharmacopœia. Remington has proposed the following formula: Dissolve gr. xvi. of hydrochlorate of morphine in ʒ i. of water and fl. ℥ i. of alcohol: add to this chloroform, fl. ʒ iij.; tincture of cannabis indica, fl. ʒ ij.; tincture of capsicum, ♏ xviij.; oil of peppermint, ♏ iv.; dilute hydrocyanic acid, ♏ xxiv.; and perchloric (or hydrochloric) acid, fl. ʒ ss. Each fluidrachm contains gr. i. of morphine. Oldberg gives the following as an imitation of the original chlorodyne: chloroform, 140 c.c.; ether, 35 c.c.; alcohol, 35 c.c.; molasses, 35 c.c.; purified extract of licorice, 85 gm.; hydrochlorate of morphine, 0.60 gm.; oil of peppermint, 1.20 gm.; diluted hydrocyanic acid, 70 c.c.; simple syrup, enough to make a total of 1 litre. Dissolve the morphine and the oil of peppermint in the alcohol, and add the chloroform and the ether. Triturate the extract of licorice with the syrup until dissolved, and add the molasses. Mix the syrup with the above solution, and finally add the hydrocyanic acid. The "National Formulary of Unofficial Preparations," of the American Pharmaceutical Association, offers a "chloroform anodyne" under the title *Mistura Chloroformi et Cannabis Indicæ Composita*, N. F.; Compound Mixture of Chloroform and Cannabis Indica. This preparation may be prescribed as a substitute, of definite composition, for the variable "chlorodynes." Each fluidrachm of the mixture represents about 7.5 minims of chloroform, 7.5 minims of tincture of Indian cannabis, 3.75 minims of tincture of capsicum, and gr. $\frac{1}{7}$ of morphine sulphate. It is flavored with oil of peppermint.

Edward Curtis.

CHLOROFORM.—Chloroform, chemically *trichloromethane*, or *methenyl chloride*, $CHCl_3$ (formerly called *terchloride of formyl*, and, popularly, *chloric ether*), is an ethereal body at one time obtained by distilling cautiously a mixture of chlorinated lime, alcohol, and water, but now most commonly produced by the distillation of acetone with chlorinated lime. Commercial chloroform is very frequently impure, and, though unobjectionable for external medical use, or, pharmaceutically, for solvent purposes, is entirely unfit for administration by inhalation as an anæsthetic. Under the simple title *Chloroformum*, Chloroform, the United States Pharmacopœia recognizes a purified article "consisting of 99 to 99.4 per cent., by weight, of absolute chloroform, and 1 to 0.6 per cent. of alcohol." The presence of alcohol in purified chloroform is for preservative purposes, since absolutely pure chloroform is prone to spontaneous decomposition. Chloroform is "a heavy, clear, colorless, mobile and diffusible liquid, of a characteristic, ethereal odor, and a burning, sweet taste. Specific gravity not below 1.490 at 15° C. (59° F.) or 1.473 at 25° C. (77° F.). Soluble in about 200 times its volume of cold water, and, in all proportions, in alcohol, ether, benzol, benzin, and the fixed and volatile oils. Chloroform is volatile even at a low temperature, and boils at 60° to 61° C. (140° to 141.8° F.). It is not inflammable, but its heated vapor burns with a green flame." Chloroform is affected by light, and accordingly it should be kept in dark amber-colored bottles, which in turn should be well stoppered and stored in a cool dark place. Chloroform of standard quality is now readily obtainable, but nevertheless, since an impure article is positively dangerous for use as an anæsthetic, it is well for the surgeon, before using an unknown sample, to apply the following simple tests: Pour a little of the chloroform upon a clean piece of filtering paper (or blotting paper, if filtering paper be not at hand) laid upon a clean plate or saucer. Rock the plate from side to side till the chloroform is evaporated, and as the odor of the chloroform disappears there should be no adventitious smell left to follow it. Next, shake thoroughly in a test tube a portion of the chloroform with an equal volume of distilled water, and allow the two fluids to separate by standing. The upper, aqueous portion should then not redden litmus paper, nor be affected by a five-per-cent. solution of either silver nitrate or potassium iodide.

In its action upon the animal economy, chloroform combines the properties of an irritant and a specific neurotic. It is a substance of high diffusion power, and hence capable of rapid and intense action. Applied pure to the skin in such manner as to prevent its being dissipated by evaporation, chloroform excites redness and burning pain, readily followed, if the application be prolonged, by blistering. Absorbed into the blood it produces profound perversions of current physiological status, of which the most important are derangement of the cerebral faculties, beginning with emotional excitement and ending in entire unconsciousness; derangement of sensation, shown most markedly in exaltation of the hearing and dulling of the tactile sense; and derangement of motility—first tremblings, or even spasms, and exaltation of reflex activity, and, later, paresis, paralysis, absolute muscular relaxation and abolition of the reflexes, and finally, if the dose be sufficient, arrest of action of heart and lungs. As seen clinically in the inhalation of diluted chloroform vapor for the production of anæsthesia the essential phenomena present themselves as follows: Very shortly after beginning the inhalation, the subject shows emotional derangement generally analogous to that seen in alcoholic intoxication, but, as a rule, of more quiet tone. In the case of naturally calm and self-contained individuals, all expression of emotional perversion may be absent, the subject passing to perfect unconsciousness without a word or a movement. As a rule, furthermore, the period of active emotional display is short, and unconsciousness supervenes not much later than four minutes after the beginning of the inhalation. Meantime, in the matter of affection of the senses, the hearing has been excited so that noises seem enormously magnified in intensity, while the tactile sense, on the contrary, has been progressively dulled. This latter effect—anæsthesia, the most important, therapeutically, of all the effects wrought by chloroform—begins earlier and is relatively more pronounced than in intoxication by either alcohol or ether. So great is the sensory dulling, indeed, that surgical procedures, except upon the most acutely sensitive parts of the body, may be practised without pain in many cases long before muscular relaxation is complete, and even while considerable conscious intelligence remains. Motor disturbances commonly begin with a moderate degree of rigidity, which, after a flitting general tremor just as consciousness fails, quickly gives way to a condition of relaxation. During the evolution of these various phenomena the respirations have at first quickened and then slackened, until at last they have become shallow and slow; the heart has also at first quickened its pulse rate, then reassumed the normal, and later taken on a more rapid but feebler action; and the pupil has at the beginning dilated, and then contracted, and redilates only with progressive advance of the intoxication, when the coma has become dangerously profound. By the march of these various phenomena the subject is brought to a condition where consciousness is lost, the muscular system relaxed, respirations are quiet and shallow, rate and quality of pulse not far removed from the normal, the pupil is still rather contracted, and reflex winking upon touch of the conjunctiva still slightly manifested. This condition is as far as the intoxication need be carried for surgical purposes under ordinary circumstances, and should therefore be recognized as the limit of effect sought to be attained under such circumstances. If the chloroform be further pushed, the respiration becomes stertorous, the heart's action grows more rapid and weak, the pupils dilate, and all reflexes cease; and, next and last, if the inhalation still continue, pulse and breathing fail and the subject dies. Upon discontinuing a chloroform inhalation, the return to consciousness is comparatively rapid, and there is but little tendency to succeeding nausea, headache, or other malaise.

Such are, in brief, the main phenomena ordinarily seen in chloroform narcosis, but departures from this normal course may occur, of which the most notable are unnatural intensity and prolongation of the period of emotional excitement; unduly strong and persistent spasmodic symptoms, and, most important of all, sudden failure of heart and respiration. Prolonged and high excitement and strong muscular rigidity, or spasms, very commonly occur together, and are most frequent in the case of hard drinkers, who take chloroform, as they take all anæsthetics, very badly. Heart-and-lung failure, likewise, is prone to occur in just such cases, but can also happen in an inhalation progressing in perfectly normal fashion, and when so occurring, is most common in subjects in the height of health and vigor. Strong and active males in the prime of life, who take chloroform on the occasion of some trivial surgical procedure, thus constitute the class that furnishes the majority of instances of chloroform collapse. With children the accident is rare, and with parturient women rarest of all. In the latter class of subjects the presence of pain very likely counteracts any possible tendency to syncope. Collapse may occur at any stage of the narcosis, or even after the subject has wellnigh wholly recovered therefrom, but is far more common, however, in the earlier stages, generally before consciousness is lost. It may come on quite suddenly after a brief period of faltering respiration, or it may follow great and prolonged excitement, violent struggling, or strong and continued muscular rigidity or convulsions, or vomiting.

The picture is like that of shock. Suddenly the breathing falters, and almost on the instant the pulse fails, the face blanches, the eyes glaze, bleeding from cut vessels stops (supposing an operation to be in progress), and the whole aspect is that of imminent death. Ordinarily, under prompt and proper treatment, the subject revives in a very few minutes, but occasionally he does not, and another "death from chloroform" is entered on the discredit account of surgical annals.

The determining cause of chloroform collapse is an overdose of the drug. Overdosage may come about in several ways. If the subject is an old toper, or is predisposed to heart failure by reason of shock, fatty heart, congestion of the lungs, or uræmic or septicæmic poisoning, the *normal* dose of chloroform is for him an *overdose.* Again, even in the case of a sound subject, a normal dose, in the sense of a normal chloroform strength of vapor, may lead to overdosage by reason of suddenly occurring quick and deep respirations. Such unusually rapid and full breathing always follows the giving way of a fit of rigidity or of struggling, with its attendant stoppage of breathing, and the circumstance accounts for the frequency of collapse, already noted, occurring early in the chloroformization and following a scene of excitement and struggling. Lastly, overdosage may come from an overcharge of chloroform upon the inhaler, as may easily happen where the inhaler is simply a towel or handkerchief upon which an unmeasured quantity of chloroform is dashed from time to time.

The *action* of chloroform is complex, as is the case with the ethereal narcotics generally. When blood is charged directly with chloroform, the red corpuscles shrink, and, if there be free access of air, dissolve completely in the serum, presumably as a result of oxidation of their substance. But in ordinary chloroform narcosis the percentage of chloroform in the blood is too slight to lead to any change in the blood discs. Certain of the early chloroform effects, such as coughing, holding the breath and struggling, are merely reflexes of local irritation of the air passages. But, for the rest, the essential phenomena of chloroform narcosis all result from a direct action of the poison upon the *nerve centres of the brain and spinal cord* and upon the *heart,* or its contained ganglia—an action which in the main is one of *progressive paralysis of function.* The influence, however, does not fall with equal weight upon all the parts affected. The brain is perturbed before the cord, and of the tracts of the cord, the sensory suffers earlier and more severely than the motor. The centres of the medulla succumb last, and again the motor tract resists longer than the sensory, the respiratory and vaso-motor centres holding out the very longest.

Upon the *heart,* a directly weakening influence is a characteristic action of chloroform. If chloroform vapor is blown upon the exposed heart of a frog, the organ stops beating instantly, while its musculature relaxes and refuses to respond to any kind or degree of stimulation. In ordinary chloroform narcosis, a fall of blood pressure, even possibly to zero, is a classical feature of the intoxication, and a progressive weakening and dilatation of the heart, beginning at the auricles, can be demonstrated. When the poisoning is intense, the heart beats more slowly as well as more feebly, and stops at last in diastole.

Just what is the *pathology of chloroform collapse* has been a subject of dispute for many years. Some have held it to be heart failure, pure and simple, due to direct action of the poison upon the heart or its contained ganglia, while others, though admitting that the heart suffers a direct weakening, yet maintain that there never is a primary cardiac paralysis, but that death begins always in the centres of the medulla—respiratory or vasomotor. This latter belief received a strong impetus from its reaffirmation by the second Hyderabad Commission.* According to Hare †—himself a later experimenter with chloroform under commission from the Nizam of Hyderabad—the chain of cause and effect in chloroform collapse is *primary paralysis of the vaso-motor centre,* whereby vascular control wholly disappears, the blood collects in the veins, and the subject dies as he would die from actual hemorrhage, by failure of respiration and of heart through lack of blood to nourish the respiratory centre on the one hand, and to excite and maintain the contractions of the heart on the other.

Whatever be the true explanation of chloroform collapse, the following *clinical* points seem now to be established: In extreme chloroform narcosis the *respiratory* function always fails before the *cardiac;* but if a faltering of the breathing, when it occurs, be not detected instantly and treated promptly and properly, the associated heart failure will follow surely and swiftly and will at once imperil life. The time elapsing between failure of respiration and the succeeding failure of heart action will vary with the chloroform strength of the inhalation. If the narcosis is produced by a prolonged inhalation of low chloroform percentage, the heart may beat for two or three minutes after the breathing has stopped; but if a strong percentage is used, the one failure of function will follow upon the heels of the other so quickly that the two will seem to be simultaneous.

Chloroform has but little action on the *nerves,* or, except in the case of the heart, upon the *muscles,* unless the narcosis has been prolonged or repeated. In such latter cases, however, chloroform may cause a temporary fatty degeneration, affecting not only the muscles, but also the liver and kidneys. Ordinarily this condition disappears after a few days, but while it endures, it is obviously a possible source of danger, and indeed accounts for occasional *late* deaths after chloroform narcosis.

Body temperature falls during chloroform narcosis, mainly as a consequence of muscular inaction.

Elimination of absorbed chloroform is principally by the lungs and kidneys, and the greater bulk of the poison escapes unchanged.

The *therapeutic applications* of chloroform are *locally* as an addition to liniments for rubefaction, or, in dilute mixture, as an anodyne for the relief of itching or of surface pains; by the *stomach,* principally as an antispasmodic, notably in intestinal colics, where the power of chloroform is unrivalled; and by *inhalation,* as an antispasmodic, an anodyne, or, carried to full narcosis, as an anæsthetic in surgical procedures.

For the *local* uses of chloroform the United States Pharmacopœia offers *Linimentum Chloroformi,* Chloroform Liniment, a preparation compounded of chloroform, three parts, and soap liniment, seven parts, by measure. In continuous application as an anodyne, this liniment should be applied under some air-proof texture to prevent the dissipation of the chloroform by evaporation. Chloroform is also much used as a local anodyne in the form of an extemporaneous ointment, made by incorporating one part of chloroform with eight or nine parts of some simple fatty basis.

For *giving by the stomach,* chloroform itself may be prescribed in extemporaneous mixture with glycerin, mucilage, or syrup. The dose ranges, for an adult, from a few drops to a teaspoonful. The latter dose, however, is a large one: it will be apt to produce decided narcotic symptoms, and often, also, vomiting. If ordered by drops, it must be remembered that the drop of chloroform is unusually small, the number required to fill the measure of 4 c.c. (fl. ʒ i.) ranging from one hundred and eighty to two hundred and seventy, according to the circumstances of the dropping. Most commonly chloroform is given internally in the form of one or other of the following official preparations of the United States Pharmacopœia: *Spiritus Chloroformi,* Spirit of Chloroform. This is a solution of chloroform in alcohol of the strength of six per cent. of chloroform by measure. Dose, anywhere up to a teaspoonful, diluted in some form of mixture. *Emulsum Chloroformi,* Emulsion of Chloroform, is compounded of chloroform, expressed oil of almond, tragacanth and water, the chloroform being present in the proportion of four parts, by measure. This emulsion keeps well, dilutes smoothly with water, and so forms a convenient preparation for the giving of chloroform. Since it contains no alcohol, the dose may be proportionately greater than that of the spirit just described, and may be set at from one to two tablespoonfuls. *Aqua Chloroformi,* Chloroform Water. This is simply a saturated solution of chloroform in distilled water, and is necessarily a feeble preparation, since chloroform dissolves in water but sparingly (1 part in 200). The water may be given, by itself, in doses of one or two tablespoonfuls, but it is more commonly used as a watery menstruum in composite prescriptions, wherein the chloroform of its composition acts as a preservative.

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* See the Lancet for the year 1890.

† The Therapeutic Gazette, February, 1897.

For *administration by inhalation,* only purified chloroform of known good quality is to be used. It is most commonly employed without admixture of other substances, the vapor being breathed, diluted with air. Whether the inhalation be a few whiffs only for the relief of pain or spasm, or whether it be for the establishment of full narcosis for anæsthesia, the fundamental principle must be observed to administer the vapor *sufficiently diluted.* Air overcharged with chloroform vapor is certain and swift death to all animal life, and the proportion of admixture for human inhalation should not exceed, for *continued* use, three and a half per cent. of chloroform to air. When, therefore, chloroform is administered by the homely apparatus of a handkerchief or towel, the points should be observed not to put more than half a teaspoonful or so of the agent upon the towel at any one time, and to hold the cloth free from immediate contact with the face, so that the inhaled vapor may be mixed abundantly with air. It is in this way that brief inhalations are practised for anodyne and antispasmodic purposes. And partly, perhaps, because of their brevity, and partly because of the existence of pain on the occasion of the inhaling, accidents during such brief inhalations are rare. Accidents, however, may occur if the chloroform is *self*-administered by a subject in the recumbent posture. For in such case, if unconsciousness supervenes, the chloroform-charged handkerchief is liable to fall directly upon the upturned nose and mouth, and there to remain, delivering possibly dangerous charges of vapor to the now narcotized subject. Accordingly, self-administration never should be practised unless the subject's head is raised sufficiently so that in the event of unconsciousness the hand and handkerchief will certainly fall down and away from the face, and the inhalation thus automatically be stopped. But under any circumstances chloroform is a dangerous drug for self-use.

The giving of chloroform to the degree of *narcosis,* for *anæsthesia in surgical procedures,* is a special topic, treated in this work in the following article, to which the reader is referred.

A last mode of using chloroform medically is by *deep injection,* by means of the hypodermatic syringe, for the relief of neuralgia. About 2 c.c. (fl. ʒ ss.) is injected at a dose, but the procedure is a harsh one, severe local reaction having several times followed the practice.

In the matter of the *toxicology* of chloroform, the first point to note is that chloroform taken by swallowing, even undiluted, is much less dangerous than would be supposed. The smallest fatal dose of which the writer has read was a drachm taken by a child four years old (Taylor). Boehm ("Ziemssen's Cyclopædia") mentions half a fluidrachm as a fatal dose, but does not give the age of the subject. On the other hand, cases have been reported of recovery after doses of from half an ounce to four ounces (presumably fluidounces). The symptoms, in poisoning by swallowing, are the production of a narcosis generally similar to that induced by inhalation of chloroform, accompanied in many cases by gastric troubles due to the direct irritation of the potion. The treatment must be conducted upon general principles, since there is no chemical antidote to the drug. Belonging to the subject of toxicology is the question whether it is possible to narcotize a sleeping person by chloroform inhalation without the subject's first awakening from the natural slumber so as to become cognizant of the attempt. And from recorded cases and the results of experiments, there seems to be no doubt but what the question is to be answered in the affirmative, *if the subject is in sound sleep* when the administration is made. But otherwise the attempt will certainly be recognized.

Edward Curtis.

CHLOROFORM, ETHER, AND OTHER ANÆSTHETIC AGENTS, ADMINISTRATION OF.—Before taking up the administration of the individual anæsthetics it will be well briefly to consider certain questions of a general character relative thereto, as the choice of the anæsthetic, the preparation of the patient, etc.

In view of the marked differences which exist between the actions of the several anæsthetics, it is evident that in certain cases the conditions presented by the state of the patient, the nature of the operation, etc., may render the use of one agent more suitable than another, and it has come to be a well-recognized fact that a judicious choice of the anæsthetic, especially in cases presenting unusual features, is, to all concerned, an important factor in the satisfactory conduct of the case. In the choice of the anæsthetic the first consideration is undoubtedly the safety of the patient, and it follows that in ordinary cases that agent should be employed which will least endanger the life of the patient. Omitting the important rôle of local anæsthesia and the use of those unusual agents whose true position as to safety has not as yet been determined, we are brought to a consideration of the relative safety values of nitrous oxide, ether, and chloroform.

The statistics of anæsthesia, like other statistics, may be selected and manipulated in such a manner as to prove the particular views of a given writer whether he favors one or the other anæsthetic. Good examples of the fallacy of individual statistics or those derived from small groups of cases, are furnished by the report of Laurie, showing 50,000 consecutive chloroform administrations without a death, and that of Anstie, showing 21 deaths in 3,058 chloroform administrations. It is obvious that to determine rightly the proportion of fatalities to administrations, individual statistics and smaller groups from various reliable sources should be put together till a large mass has been formed, the deductions from which must be of the greatest possible value:

	Administrations.	Deaths.	Rate.
Statistics collected by Julliard:			
Chloroform	524,507	161	1 in 3,258
Ether	314,738	21	1 in 14,987
Statistics collected by Ormsby:			
Chloroform	152,260	53	1 in 2,873
Ether	92,815	4	1 in 23,204
Statistics collected by Gurlt in Germany from 1891 to 1897:			
Chloroform	......	....	1 in 2,039
Ether	......	....	1 in 5,000
Statistics from St. Bartholomew's Hospital from 1875 to 1890:			
Chloroform	19,526	13	1 in 1,502
Ether	8,491	3	1 in 2,830
"Gas and ether"	12,941	1	1 in 12,941

There are very few reported deaths from nitrous oxide, and considering the many millions of administrations that have taken place, the *rate* of its mortality would probably be one in several hundred thousands.

It is the writer's opinion that the statistics of anæsthesia are particularly unreliable and misleading owing to unreported fatalities, of which there are probably a far greater number than of those reported. Julliard has given particulars of 20 deaths by chloroform that took place within his knowledge, only 3 of which had been published. Waller refers to 3 cases not reported, and mentions one hospital from which 2 chloroform deaths were reported out of 9 that occurred during one year.

Another source of error in these statistics is the fact that the fatalities reported are, for the most part, those which are due to the *immediate* effect of the anæsthetic, while the cases that die subsequently from conditions which may be attributed partly or wholly to the anæsthetic are more apt to be unrecorded. Ether probably furnishes a greater number of these cases than chloroform, and in consequence the statistics of this anæsthetic are probably more favorable than the whole truth of the matter warrants. It is therefore probable that nitrous oxide is the safest general anæsthetic if its use is restricted to momentary administration as for tooth extraction. The prolonged administration of this anæsthetic is quite a different matter, however, and at the present time there are not sufficient data of its use in this way to warrant conclusions as to its safety. The writer has administered gas with air or with oxygen for operations lasting from a few minutes to more than two hours in several hundred cases, and while he has had no death, alarming states have several times appeared with such rapidity and so little warning that it seems probable that the general adoption of this form of anæsthesia would lead to a mortality more nearly approximating, if not exceeding, that of chloroform and ether. This opinion is strengthened by the occurrence of four such deaths in New York City which have come to the writer's notice within one year.

Ether is undoubtedly *second* in safety, whether used alone or following nitrous oxide.

Chloroform is the most dangerous of the agents under consideration.

In mixtures such as A. C. E. the most active ingredient is chloroform, the effect of which is modified by dilution and by the action of the other elements of the mixture. In point of safety these mixtures should probably be placed between ether and chloroform, the greater the proportion of chloroform the more dangerous the mixture.

It is thus evident that from the standpoint of statistics the choice of the anæsthetics should be as follows:

First, nitrous oxide for such operations as necessitate *no more* than one complete administration of the gas.

Second, ether, whether given alone or preceded by nitrous oxide.

Third, a mixture such as A. C. E.

Fourth, chloroform.

There are, however, other factors than statistics to be considered before a proper choice can be made, and these are found in connection with *the condition of the patient* and *the nature of the operation.* Conditions of the patient affecting the choice of the anæsthetic are as follows: Age is responsible for the presence of certain conditions which may modify the effects produced by the different anæsthetics and consequently their safety. It is a popular belief that chloroform is the ideal anæsthetic for children, and that they possess an immunity from its dangerous action not enjoyed by adults. The statistics of anæsthesia prove this to be without foundation, and would rather indicate a greater relative mortality in these subjects, as would seem reasonable in view of their delicate constitutions. In the *Lancet's* investigation of the chloroform question, out of 406 chloroform deaths in which the ages were stated, 58 were fifteen years old or younger. This relative mortality of nearly fifteen per cent. in children is large when we take into account the fact that this age furnishes but a small percentage of the cases requiring anæsthetics.

Ether, if presented in concentrated vapor, is very irritating to the delicate mucous membrane of the air passages of infants and young children, and the respiration may become greatly obstructed by the excessive flow of mucus and saliva thus set up. A properly diluted vapor of ether is well borne by these patients, however, and by careful administration anæsthesia may be accomplished without undue irritation, although mucus and saliva are usually more abundant than in adults. Infants and very young children are easily asphyxiated by nitrous oxide, and the period of anæsthesia resulting from a single administration is so short in these patients that its use is rarely advisable. Older children take gas more satisfactorily, although the period of anæsthesia is much shorter than in adults, and reflex phenomena are more pronounced. Age again becomes a factor in the choice of the anæsthetic in those of advanced years. Here, the impaired respiratory power, the tendency to bronchial affections (or their presence) and to alterations in the blood-vessels, render the use of ether more dangerous perhaps than at any other time of life. The danger of chloroform in reference to these conditions is not particularly affected, and chloroform is thus brought into favorable contrast with ether in the aged.

The mere age, however, should not altogether govern the choice of the anæsthetic without reference to the conditions presented by each patient. Many very old persons take ether perfectly well, and there are some who would be greatly endangered by chloroform.

Nitrous oxide with oxygen may occasionally be of service in the aged under circumstances which would render the use of ether or chloroform particularly dangerous. Exceedingly fleshy individuals are not, as a rule, good subjects for nitrous oxide or ether owing to the fact that they are very liable to difficulties with the respiration under these anæsthetics. Chloroform or chloroform mixtures are better taken by this class of patients. The condition of the heart is occasionally a factor in the choice of the anæsthetic. The presence of valvular lesions with perfect compensation does not materially affect the choice of the anæsthetic, as these patients take anæsthetics in the usual manner. When compensation is not perfect and the patient suffers from dyspnœa, cyanosis, cough, œdema, effusions, etc., the use of an anæsthetic is more or less hazardous, and a proper choice will greatly enhance the patient's safety. The presence of dyspnœa, cyanosis, and cough contraindicates the use of ether and nitrous oxide. Chloroform is perhaps more suitable for these cases, particularly if oxygen is administered with it. In all cases with heart disease it is advisable to avoid the struggle which frequently occurs during the period of excitement, and this should be done *when possible* by the administration of gas followed by ether.

Many prefer the A. C. E. mixture in these cases, and it is probable that if any one anæsthetic were to be chosen for all of this class of cases, such a mixture would be best.

Anæsthetics are especially dangerous in cases presenting degenerative changes in the heart muscle. Chloroform particularly, and ether, or A. C. E., should be preferred according to the indications present.

Disease of the blood-vessels may affect the choice of the anæsthetic. Marked atheroma contraindicates ether, chiefly on account of the danger of cerebral hemorrhage from the elevation of blood pressure which accompanies its use.

Chloroform or A. C. E. would be preferable here, as in cases with aneurism. Nitrous oxide should not be administered to these patients in the usual way. Its use would only be justified when combined with sufficient oxygen to obviate the asphyxia which would otherwise result and which would be dangerous under these circumstances.

The presence of acute disease of the lungs is a contraindication to the use of ether, and whenever such conditions have recently been present this agent should be administered with great care, if at all. Chronic pulmonary complaints are apt to become more active after the administration of ether, particularly in old persons. In cases of slight or quiescent pulmonary tuberculosis ether is apt to be harmful and should be avoided if possible.

Patients who are liable to pulmonary hemorrhage should not have ether. In this class of cases nitrous oxide with oxygen, chloroform, or A. C. E., is preferable to ether.

Active disease of the kidneys, acute or chronic, constitutes an indication for great care in the choice of the anæsthetic. It is very generally accepted that ether is more damaging to *diseased* kidneys than chloroform, and this is borne out by clinical experience. Nitrous oxide with oxygen probably disturbs the kidneys less than any other general anæsthetic, and should be the first choice in cases presenting nephritis, while chloroform should be second.

Patients who are particularly exhausted, collapsed, or anæmic are greatly endangered by chloroform. Ether is preferable for these cases.

The presence of dyspnœa, as caused by the pressure or direct intrusion of tumors on the air passages, stenosis of the same from false membrane or from the presence of foreign bodies, compression of the lungs by effusions, interference with respiration from abdominal distention or paralysis of the respiratory muscles, is a contraindication to ether or nitrous oxide. Chloroform alone or as in A. C. E. is preferable, especially when administered with oxygen.

Comatose or semi-comatose patients require little if any anæsthetic and are easily brought into a dangerous condition if much is employed. The choice should be governed by the conditions present.

Insanity does not appear from clinical evidence to indicate the use of one particular anæsthetic rather than another, and the choice in these cases should be determined by other factors than the mental state.

Circumstances connected with the operation to be performed often have a determining influence upon the selection of the anæsthetic. The sitting posture as usually required for tooth extraction, and occasionally for operations upon the tonsils and adenoid growths in the pharynx, is a distinct contraindication to the use of chloroform, and the many fatalities which have attended its administration under these circumstances are sufficient warrant for the statement that *chloroform should never be administered to a patient in the sitting position.*

In operations on the brain chloroform is frequently preferred to ether on account of causing less congestion. In operations about the mouth and nose, when it is necessary that the effect of the anæsthetic be maintained beyond a brief period, the narcosis is best continued by chloroform from a Junker apparatus, although ether may be administered before the operation begins.

For abdominal operations chloroform is preferred by many operators on account of the greater quietude of the abdominal muscles and the less vigorous form of respiration than frequently accompany the administration of ether, though it is possible with the latter anæsthetic to produce satisfactory results in the majority of these cases by proper administration.

In operations upon the large joints, particularly the reduction of dislocations, upon the rectum, the deep glands of the neck, the kidney, and for intestinal obstruction ether is preferable to chloroform on account of the unusual tendency to shock which attends these operations. Many fatalities have been recorded from chloroform in these operations. The same is held to be true of operations in which the optic nerve is severed.

In obstetrics much may be gained by a proper selection of the anæsthetic. There are two conditions in these cases which call for the use of anæsthetics, one being for the relief of the pain attending labor, the other for obstetric operations. Since Simpson, in 1847, first advocated the administration of chloroform for the relief of pain in labor, this agent has been almost universally used for this purpose and almost to the exclusion of other anæsthetics. It has been thus administered in a vast number of cases, and very few fatalities have occurred. Indeed, the administration of chloroform is held to be, and probably *is*, particularly safe during the latter part of pregnancy owing to the increased power and tone of the vascular system and the heightened resistance of the body generally. There are, of course, exceptions to this rule —patients to whom chloroform must be dangerous under any circumstances—and these should not be endangered through mere routine.

The simplicity of the administration of a few drops of chloroform to relieve a labor pain and the delightful result produced practically without danger or discomfort, give to this anæsthetic a place that will not soon be held by another agent.

The use of ether as an analgesic during labor has never been extensive; and while ether is at a disadvantage as compared with chloroform in point of comfort and simplicity of administration, it possesses certain advantages which are often desirable and which will be considered later. The writer has used ether for this purpose in many cases with the utmost satisfaction.

In obstetric operations surgical anæsthesia is usually required, and in the selection of the anæsthetic certain points in connection with the patient's special condition should be considered.

The effect of the different anæsthetics upon the uterine contractions, and the rapidity of the recovery of the uterus from the effects of the anæsthetic, are important. Used simply as analgesics in labor there is very little effect upon the uterine contractions, as a rule. Such effect, however, is in direct proportion to the amount employed, and is manifested by lessened force and frequency of the "pains." The writer is not aware whether ether or chloroform is more liable to such action, but would point out the difference in the effects of these two agents when administered to the more profound degree necessary for obstetric operations. Hensen, Dunhoff, and others have demonstrated that ether and chloroform diminish the force of the pains, prolong the interval, and lessen or suspend the action of the abdominal muscles. The force of the pains is quickly restored after ether, very slowly after chloroform. Hensen, therefore, considers that ether should always be used as the anæsthetic in labor.

Preparation for the Administration.—From the standpoint of the anæsthesia a number of details of preparation for the administration are of much importance. The general condition of the patient should be carefully noted several days before the administration. The heart, lungs, and kidneys should be thoroughly investigated. If the patient's condition can be improved or fortified in any way against danger from the anæsthetic it should be done. The influence of digitalis, strychnine, etc., for several days before the operation is often beneficial in counteracting possible depression from the anæsthetic or shock from the operation. In cases in which considerable hemorrhage is liable to occur during the operation, the vessels should be well filled by the ingestion of considerable quantities of fluid for several days prior to the operation. The patient's stomach should be as nearly empty as possible at the time of the operation without withholding nourishment to the extent of producing weakness. It has been the experience of many observers that from three to six hours should elapse between the taking of solid food and the administering of the anæsthetic, preferably the longer time. The length of this period is, however, of less importance than the character of the food last taken, regarding which I should say that the worst possible consisted of meat, vegetables, and milk, and the best, of clear soup, beef juice, or some other non-coagulable fluid of distinct nutritive value. Aged and weakly patients should be treated more leniently in respect to the withholding of nourishment than the young and strong. Whenever it is found desirable that the patient should have nourishment less than three hours before the operation, it should be administered by way of the rectum. The same is true of alcoholic stimulation, which is sometimes desirable shortly before the operation. A condition is occasionally met in cases of intestinal obstruction in which the stomach contains material which has passed into it from the bowel and which is being vomited with little or no effort (regurgitative vomiting). The danger of infection of the lungs through aspiration of some of this material during narcosis is considerable, and if possible the stomach should be thoroughly washed out before the administration.

While the time of the narcosis is usually determined by other circumstances, it is well to bear in mind that the patient's condition is usually best at about eight in the morning and two in the afternoon. As regards the relation between fasting and the patient's general condition, the early morning presents the favorable circumstance of a prolonged fast which is natural and which does not produce the weakness and faintness often felt in passing the usual meal-time. Although an empty stomach is not as essential before a brief administration of nitrous oxide as before ether or chloroform, it is still very desirable and should always be so arranged if possible. It is customary to have the bowels well evacuated before operations, and a number of points have been observed in this connection which bear upon the anæsthesia and the condition of the patient. A drastic and vigorous cathartic the night before a morning operation is very apt to leave the patient not only in a weakened condition but "ill" by reason of headache, nausea, vomiting, and general malaise. The administration of laxatives for several days before the operation, together with regulation of the diet, would seem to accomplish the purpose more satisfactorily. The rectum and bladder should be empty. This should not be overlooked in brief administrations of nitrous oxide, especially in children, for there is a distinct tendency toward evacuation of these organs under this anæsthetic. Before the administration of an anæsthetic, arrangements should be made for the proper protection and care of the patient during the narcosis.

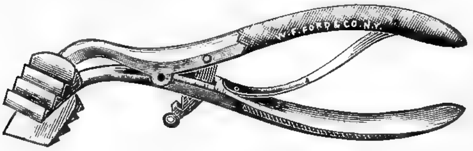

FIG. 1264.—Gross' Mouth Gag.

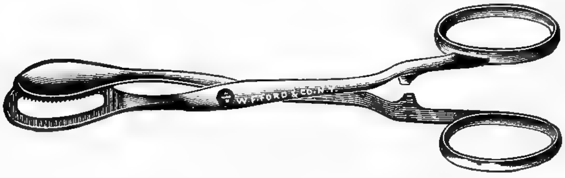

FIG. 1265.—Mathieu's Tongue-Holding Forceps.

Ample covering should be provided during the operation, and this is a point frequently overlooked or inadequately carried out. The table should be padded to a comfortable degree if possible, and undue pressure upon any part of the patient should be prevented. Particular care should be taken that the arms and legs do not hang over the edge of the table, for many cases of paralysis result in this way. The position of the patient should be as natural and unrestrained as possible in view of the requirements of the operation. Apparatus used to maintain certain positions, as the crutch for the lithotomy position, and shoulder rests used in the Trendelenburg posture, should be well padded and not too tightly applied. When the arms are to be extended over the head during the narcosis they should not be *over-extended*, for paralyses have been caused in this way.

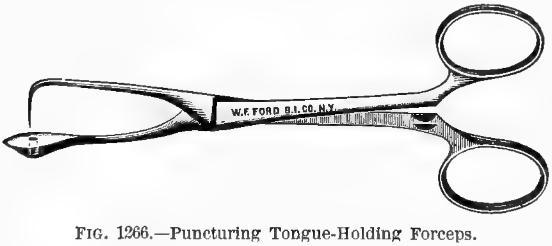

FIG. 1266.—Puncturing Tongue-Holding Forceps.

The administrator should have at hand and ready for use *a mouth opener* such as a wedge of hard wood, a wooden conical screw, or some such instrument as that shown in Fig. 1264, a forceps for grasping the tongue as shown in Fig. 1265. A tongue-holding forceps which pierces the tongue is useful for such cases as require the tongue held forward for prolonged periods, causing less after disturbance than the grasping forceps. An excellent tongue-piercing forceps is shown in Fig. 1266. A mouth gag for holding the jaws apart is often required (see Fig. 1267). Mouth props as shown in Figs. 1268 and 1269 are necessary for dental cases.

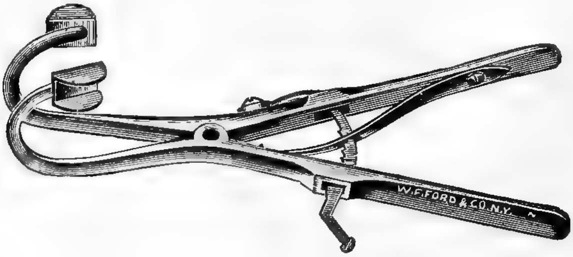

FIG. 1267.—Denhart's Mouth Gag.

The following should also be at hand: A number of small swabs should be *fixed* upon handles or sponge forceps ready for use. A number of towels, a small basin, a hypodermic syringe *in working order*, and various stimulants in solution or tablet form, including strychnine, nitroglycerin, digitaline, atropine, etc., a trachea tube, and instruments necessary for tracheotomy, and in major cases it should be seen that apparatus for infusion is ready. A stomach tube is occasionally useful.

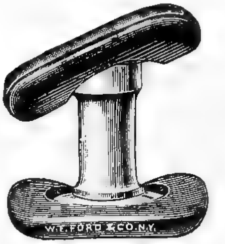

FIG. 1268.—Hewitt's Mouth Prop.

THE ADMINISTRATION.—*Principles of Administration.*—At the time of the administration the patient should assume a natural and comfortable position. The clothing should be loose everywhere. The presence of removable artificial teeth or other loose bodies in the mouth should be ascertained and such should be removed. The nares should be free from foreign material. Natural quiet should be maintained at the beginning of the administration and until anæsthesia is complete. Unnatural quiet and whispering should be avoided. The patient should be encouraged in a confident manner, for encouragement lessens fear and fear produces a kind of shock which increases the danger of anæsthetics, especially chloroform. The effect of the anæsthetic up to the time of unconsciousness should be briefly explained to the patient. He should be instructed how to breathe, naturally but with slightly more vigor than usual, not excessively.

The best position for the head during the administration is a matter of great importance. If a pillow is used, it should be small and should extend beneath the shoulders far enough to cause the head to assume a moderately extended position over its upper edge. The face should be turned well to one side, though not to the extent of interfering with the respiration. In this position the tongue has less tendency to obstruct the respiration, and drainage from the mouth is favored. The administrator should never lose sight of the seriousness of anæsthesia. He should be familiar with its statistics and should remember that too great a belief in the safety of any one of the anæsthetics constitutes one of its dangers. Too much must

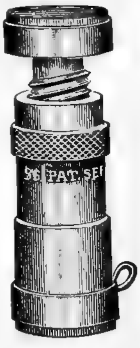

FIG. 1269.—Daintree's Adjustable Mouth Prop.

not be trusted to an *apparatus*, and it should be remembered that perhaps "the best apparatus is a good man."

Inhalers should be handled carefully and kept clean for each case. Only anæsthetics "especially prepared for inhalation" by chemists of known reputation should be employed. Chloroform is known to decompose even in the bottle if exposed to direct sunlight for a short time or to ordinary daylight for a prolonged period. Chlorine and hydrochloric acid are thus liberated, and the chloroform is rendered irritating and unfit for use. Chloroform vapor is decomposed by an open flame into carbonyl chloride (phosgene gas), an intensely acrid and pungent gas which causes great irritation of the eyes and respiratory tract. So great is the irritation of this substance that a number of deaths have been attributed to its effect upon the lungs through breathing it in operating-rooms where chloroform was used in the presence of open lights and where ventilation was poor. These deaths have occurred among the physicians and assistants rather than among the patients. Exposure of ether to light and air renders it unfit for use, through the formation of acetic acid and other products which give it a sharp and irritating odor. Ether is highly inflammable and its vapor in air is a violent explosive. On account of the great weight of the vapors of ether and chloroform, an open flame near the floor is more dangerous than one overhead. When chloroform is used in a room in which there is an open flame, free ventilation should be insured by drawing the windows down from the top. In practice the greatest danger from the inflammability of ether has proved to be in connection with the use of the cautery. Squibb has reported the ignition of ether vapor at a point fifteen feet from the source of the vapor.

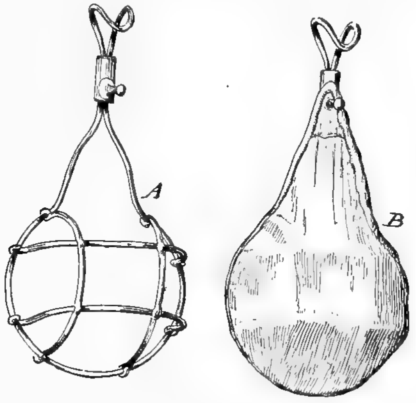

FIG. 1270.—The Esmarch Mask. *A*, The wire frame; *B*, the same with flannel cover.

During the administration of an anæsthetic the depth of the narcosis is indicated by the condition of certain functions and reflexes, upon the correct interpretation of which often rest the smoothness and safety of the administration. The chief of these in the order of their value are: the respiration, the corneal, conjunctival, and lid reflexes, the pupil. The condition of these in the different periods of narcosis has been considered under "Phenomena of Anæsthesia," Vol. I., p. 299.

It will be found in practice that no one sign can be relied upon in all cases, and it is better to take into account all of the signs at a given time rather than to depend upon any one. In children the conjunctival reflex is lost very early. In neurotic individuals the pupil is apt to remain reflexly dilated throughout the administration. The breathing, its rate, depth, sound, and alterations, is probably the best of any one sign.

The administration of the anæsthetic should be lessened toward the close of the operation, and should be stopped when all painful procedures have ceased or as soon as vomiting or slight movement will no longer disturb the operator. The patient should be watched closely by the administrator or by some other experienced person till signs of consciousness are present.

Chloroform.—Experiments by Snow, Bert, Dubois, Waller, and others, upon the percentage of chloroform vapor in air necessary to produce the surgical degree of anæsthesia with reasonable safety and in a reasonable time, show from one to five per cent. to be the required amount. The latter strength of vapor is to-day considered dangerously high, and between one and two per cent. is thought to be sufficient. Practically it must be said that our methods of administering chloroform are largely empirical and far from exact. We do not deal in known percentages, and if it were possible to do so an indefinite factor would still remain in the uncertain and irregular intake of the vapor owing to variations in the rate, depth, and regularity of the respirations. Snow, Clover, and others have devised more or less complicated inhalers for the purpose of administering chloroform mixed with air in known percentages within the five-per-cent. limit, and in the hands of the inventors these inhalers proved most satisfactory. In the hands of others, however, numerous accidents and deaths occurred in their use and they are no longer employed. *The men, and not the inhalers, produced the results.* At the present time the administration of chloroform is usually conducted in one of the following ways: From a towel; from a handkerchief; from a mask; from a Junker inhaler.

A towel has been used in several ways. In one it is folded into a square several layers thick and the chloroform, several drachms at a time, is poured upon one surface, which is held close to the face, flat, or in the form of a cone. This was the original method of Simpson and Lister, and was supposed to furnish a vapor within the limit of safe percentage. Snow and Sansom demonstrated that a dangerously high percentage might be inhaled by this plan. Another method of employing a towel is to gather one of its corners into a concave shape and use this as a mask upon which the chloroform is poured. By pulling the corner of a towel through a ring or safety pin (Lister's method) a very fair mask may be formed.

A handkerchief has often been used either in the same way as the towel or crumpled up and held in the hand or placed in a cup or tumbler, chloroform being poured upon it and held close to the face. This is a plan frequently followed in administering chloroform as an analgesic in labor, a few drops for each pain being all that is required.

Perhaps the most generally adopted plan of administering chloroform is by means of a mask, consisting of a dome-shaped wire frame covered by a piece of flannel. The Esmarch, Skinner, and Schimmelbusch masks are the most employed (see Figs. 1270 and 1271).

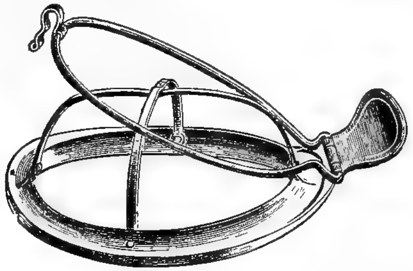

FIG. 1271.—The Schimmelbusch Mask (folding).

In the administration of chloroform by means of a towel or cone, two distinct plans have been followed. In one it has been pushed "powerfully and speedily" (Simpson) by the use of comparatively large quantities at a time, and consequently a strong vapor. This has been called the Scotch method. In the other plan small quantities at frequent intervals are used, and from the fact that a drop bottle is usually employed and the addition of the chloroform carried out a drop or more at a time at regular and short intervals, this plan is known as "the drop-by-drop method." The latter results in more accurate dosage than the former, and for that reason must be safer and is to be preferred.

Junker's inhaler (Fig. 1272) is considered by many to be an excellent means for the administration of chloroform vapor with controllable accuracy as to strength and quantity. Its use consists in forcing air to the bottom of a bottle partly filled with chloroform through which it bubbles and passes out through a tube which terminates in a face-piece of some kind, a metal tube, or a soft catheter. In ordinary administrations a face-piece is used, while in operations about the mouth and nose the tube or catheter may be passed into one or the other of these orifices and the administration proceed without interfering with the operation. In operations in which a preliminary tracheotomy is performed and the administration of the chloroform conducted through the trachea tube, an apparatus similar to that shown in Fig. 1273 is often employed. The chloroform should be used drop by drop on the flannel top of the conical mask.

With a proper understanding of the physiological action of chloroform and familiarity with the phenomena of anæsthesia (both subjects are considered in the author's article on *Anæsthetics* in Vol. I.), the administration of this agent should be conducted according to the following principles. A reasonable time for the production of complete chloroform anæsthesia varies from three to ten minutes. A very dilute vapor should at first be presented to the patient. The strength of the vapor should be increased gradually, though as rapidly as possible in view of the comfort of the patient. On account of the liability of chloroform to cause inflammation of the skin if it is held in contact with it under circumstances which interfere with its rapid evaporation, it is advisable to protect the nose, cheeks, and chin by an application of vaseline or cold cream to these parts before the administration, or as soon as the patient has lost consciousness. When unconsciousness supervenes the rhythm of the respiration will be liable to great alterations, and it should be remembered that the intake of chloroform will bear a direct relation to the vigor of the respiration, provided the supply of chloroform is a constant factor. When a sufficient depth of anæsthesia has been attained it should be continued as evenly as possible. The addition of chloroform should not be interrupted, but its amount must be lessened to the requirements of the particular case. Operative procedures should not take place while the patient is in the lighter degrees of chloroform narcosis, as dangerous or fatal collapse, probably of reflex origin, has been frequently noted under these circumstances.

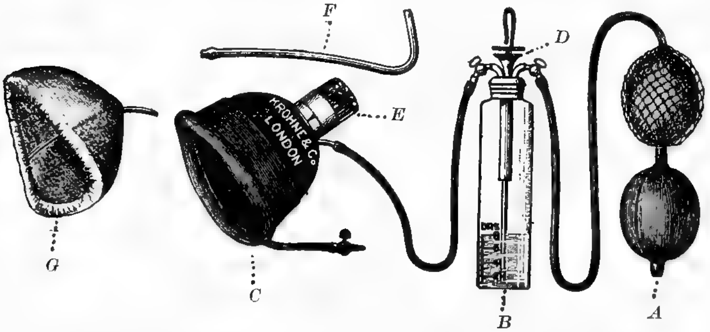

FIG. 1272.—An Improved Junker Apparatus. *A*, Hand bellows; *B*, chloroform bottle graduated to eight drachms; *C*, a hard-rubber face-piece with (*E*) feather valve to indicate respiration; *D*, funnel for addition of chloroform; above this is seen the hook used to attach inhaler to buttonhole; *F*, metal tube for mouth or nose; *G*, flannel-covered mask face-piece.

A. C. E. and similar mixtures should be administered on the same principles as chloroform, though they must be used more freely. It is not advisable to administer these mixtures from a Junker inhaler or by any other means whereby a somewhat large quantity is gradually vaporized by allowing air to pass over or through it, for under these circumstances the unequal rates of volatility of the different ingredients will result in a very different vapor toward the end of the process than that at the beginning. This is well shown by the experiments of Minor, in which 200 c.c. of a mixture of ether and chloroform in molecular proportions were distilled with the following results:

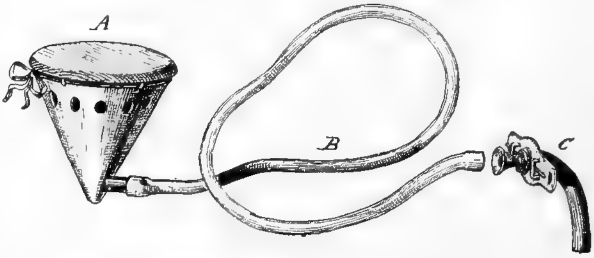

FIG. 1273.—Trendelenburg Apparatus Used with Ordinary Trachea Tube.

60 c.c.	came off, the boiling point ranging from	49°	to 53° C.
40 "	" " " " " " "	53	" 56
55 "	" " " " " " "	56	" 59
45 "	" " " " " " "	59	" 62

Smiles had estimated the percentage of chloroform vapor at different times in the evaporation of a mixture of ether and chloroform in molecular proportions by passing air through it. The results are as follows:

Amount evaporated.	Amount of chloroform in vapor.
10 per cent	14.0 per cent.
20 "	22.5 "
30 "	30 "
40 "	37 "
50 "	44 "
60 "	49 "
70 "	53 "
80 "	57 "
90 "	60 "
100 "	62 "

Mixtures should therefore be administered by the drop-by-drop method, in which event the last drops from the bottle will have the same composition as the first, and each addition of a few drops to the mask is vaporized almost at once, so that there can be no dangerous accumulation of the less volatile chloroform, which is the most active and most dangerous element.

Ether.—There are two distinct methods of administering this agent, the "open" and the "close." In the open method there is little or no attempt to limit the respired air and ether vapor to the inhaler, while the close method is characterized by such limitation, and a bag is provided in order that a certain amount of rebreathing may take place.

The chief advantages of the open method are: that a very simple apparatus or none at all is necessary; that a free supply of oxygen is furnished to the patient if the ether vapor is not presented in so high a degree of concentration as to thus limit the air; that a new and entirely clean inhaler may be furnished for each patient without trouble.

The chief disadvantages of the open method are: that the administration is apt to be prolonged, particularly in the stage of excitement and struggling; that more ether is wasted than is consumed by the patient, and this unused ether changes the air of the operating-room often to a disagreeable degree; that the after-effects are greater, probably owing to a greater degree of saturation of the patient with ether.

The advantages of the close method are: that complete anæsthesia may be produced rapidly with a comparatively small amount of ether and with comparative comfort to the patient, if a regulating inhaler, such as Clover's or the author's, is employed; that the stage of excitement and struggling is often absent, and when it occurs is usually slight and of short duration; that the ether vapor is warmed by the air from the lungs and is therefore less irritating; that the ether vapor is largely confined to the inhaler and does not impregnate the surrounding air to any extent as compared with the open method; that the patient does not appear to become as saturated with ether as by the open method, the after-effects being less as a rule.

The chief disadvantages of the close method are: that a more or less complicated and cumbersome inhaler is necessary; that this inhaler is kept clean with some difficulty; that more skill is required for the administration.

The best examples of open inhalers are found in the "ether cone" and in the Allis' inhaler. The paper and towel cone has probably been used more extensively, particularly in the United States, for the administration of ether than any other form of inhaler. It can be extemporized at a moment's notice almost anywhere from a towel and newspaper or other suitable material, and furnishes an inhaler so simple, clean, cheap, and effective, if properly used, that it will undoubtedly retain a prominent place in the list of ether inhalers. Paper and towel cones are made in various shapes and sizes, and are constructed on several plans. Usually they are cylindrical, open at one or both ends according to the ideas of the maker. The paper serves to give shape and stiffness and is impervious to air. The towel acts as a cover and furnishes a soft edge for the face. Sponges, cotton, or gauze, may be used to pack the upper end of the cone to receive the ether.

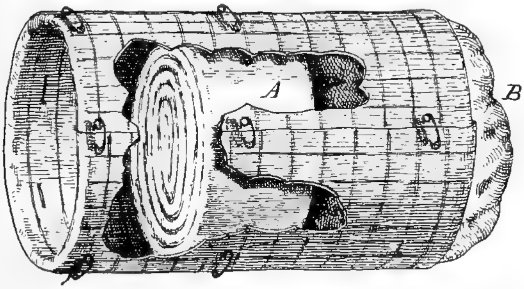

FIG. 1274.—A Paper and Towel Ether Cone. *A*, A loose roll of gauze to receive the ether; *B*, loose gauze to retard escape of ether vapor.

In the writer's opinion the best form of cone may be described as follows: Cuff-shaped, moderately stiff, at least six or eight inches long (in proportion to its diameter), open at both ends, the packing for the reception of the ether to be *fixed* in the centre of the cuff, allowing a considerable space above and below, the packing to be of some loose material offering no appreciable resistance to the passage of air through it, the space above the packing to be filled with a small quantity of loose gauze. Such a cone is illustrated in Fig. 1274. The chief objects attained in such a cone are: that a large air space is provided for the accumulation of ether vapor, the escape of which is retarded by its own weight and by entanglement in the meshes of the loose gauze above the packing; no impediment to respiration as in a cone with one end closed; a considerable space between the face and the packing which receives the ether.

A metallic cone is shown in Fig. 1275. It has an inflatable rubber face-piece. Its upper third is partitioned off by a diaphragm of coarse netting, forming a chamber for the packing which receives the ether. It is perfectly simple and is easily kept clean.

The Allis' inhaler shown and described in Fig. 1276 is extensively employed in the United States for the administration of ether, and is an excellent inhaler. It is really a modified cone, over which it possesses no special advantage.

The administration of ether by means of an open inhaler may be conducted in two ways. In one the inhaler is charged with several drachms of ether and is gradually brought toward the face as rapidly as the comfort of the patient will admit, more ether in similar quantities being added from time to time. The other plan is to apply the inhaler to the face of the patient without ether, which is to be added gradually, beginning drop by drop and increasing the amount as rapidly as may be agreeable to the patient, and more ether being added in small quantities at frequent intervals throughout the administration. Preference for one or the other of these plans is a matter of personal opinion.

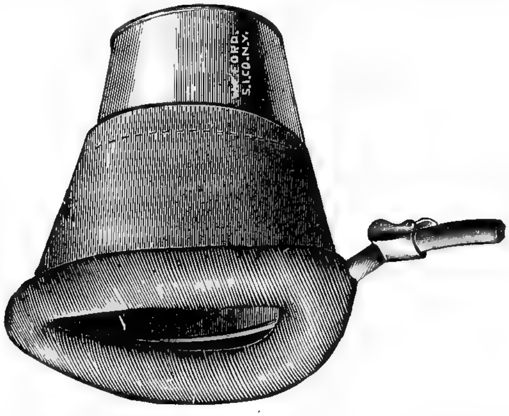

FIG. 1275.—Metallic Cone with Pneumatic Face-Piece.

Close Inhalers.—There are many close inhalers for the administration of ether, but Clover's and Ormsby's are the original and most employed types.

In Clover's inhaler the ether chamber revolves upon the shaft of the face-piece. An index pointer attached to the base of the shaft may be seen extending out beneath the bottom of the ether chamber.

When the inhaler is arranged as in Fig. 1277 air breathed back and forth through it will not enter the ether chamber proper, but will pass through the central chimney only, the index pointing to 0 (no ether). Upon rotation of the ether chamber the current of air is permitted to pass over the ether in proportion to the degree of rotation, one-half revolution bringing the index to F (full ether), in which position all of the air is made to pass over the ether on its way between the face-piece and the bag. Intermediate positions of rotation allow proportionate amounts of air to pass over the ether, and the figures 1, 2, and 3 to be seen on the side of the chamber indicate that one-fourth, two-fourths, and three-fourths respectively of the air is passing over ether.

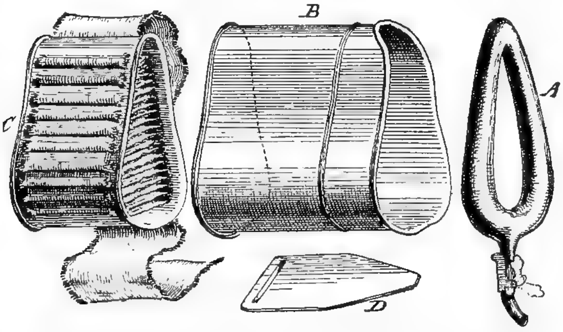

FIG. 1276.—The Allis Inhaler (Improved). *A*, Inflatable rubber face-piece; *B*, metallic cuff; *C*, frame with interwoven bandage to receive the ether; *D*, needle for passing the bandage back and forth.

The inhaler is used as follows: The ether chamber is charged with from one to two ounces of ether through D, and the index turned to 0. The face-piece is applied accurately to the face during several full exhalations so as to distend the bag. The face-piece is now kept applied, and after eight or ten respirations *without* ether, the chamber is gradually rotated from 0 toward F as rapidly as is comfortable to the patient. In from two to four minutes the rotation will usually be accomplished and the patient is in the proper degree of narcosis or nearly so.

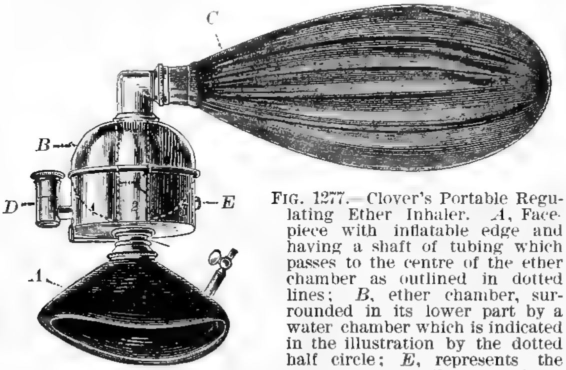

FIG. 1277.—Clover's Portable Regulating Ether Inhaler. *A*, Face-piece with inflatable edge and having a shaft of tubing which passes to the centre of the ether chamber as outlined in dotted lines; *B*, ether chamber, surrounded in its lower part by a water chamber which is indicated in the illustration by the dotted half circle; *E*, represents the screw stopper to the water chamber. The ether chamber is filled through *D*. *C*, Thin rubber bag of about one gallon capacity, detachable from ether chamber.

Average patients will not require a rotation beyond two and one-half or three, at which point the index may be kept till a proper degree of narcosis is reached. During this rotation the face-piece should be kept closely applied and no fresh air admitted unless too marked cyanosis appears; some duskiness is to be expected. When the signs indicate the proper degree of anæsthesia, or before that time, if the cyanosis becomes too great, a number of respirations of pure air should be given by removing the inhaler from the face. After maintaining a proper anæsthesia for several minutes with the index at 2½, 3, or F, it may be moved to a point between 1 and 2, at which the desired level of narcosis is found to be maintained, and from this time on a number of respirations of fresh air must be admitted by removing the inhaler from the face from two to four times a minute. Under these circumstances the normal color should soon return. More ether must be added from time to time as necessary. In cold weather and for unusually vigorous subjects it is advisable to fill the water chamber, which surrounds the ether chamber, with *warm* water through the tap E before the administration.

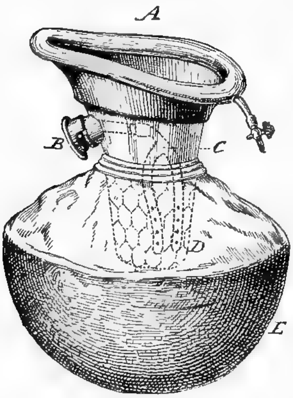

FIG. 1278.—The Ormsby Ether Inhaler. A, Face-piece with inflatable rubber edge (detachable); *B*, tap for admission of air and addition of ether, which passes to the cage *D* through the tube *C*; *E*, the rubber bag which permits re-breathing.

Ormsby's inhaler has been variously modified, and with slight changes is known by several different names as Parkinson's, Davis', etc. It is really nothing more than a metallic cone with a tightly fitting face-piece, a bag to allow re-breathing, and an air tap to admit fresh air. Connected with this tap is a small funnel and tube for the purpose of adding ether to the packing. This arrangement for adding ether is not practicable and is rarely used. It is better omitted as it interferes with packing the cage and with the admission of air through the tap.

To use Ormsby's inhaler the cage D is packed moderately full of sponge or gauze; if a sponge is used it should be wrung out of warm water. Half an ounce of ether is now added to the packing, and the inhaler is brought into position on the face as rapidly as the strength of the vapor will permit, the air tap B being wide open and the patient encouraged to breathe deeply. When the face-piece is in position the air tap should be gradually closed and the inhaler kept applied to the face till anæsthesia is complete. This is often accomplished without further addition of ether. The air tap should now be opened fully or half-way and the administration continued, ether being added several drachms at a time at moderate intervals or smaller amounts more frequently.

The ether inhaler shown in Fig. 1279, and in sectional view in Fig. 1280, is one the author has devised with the idea of combining in one instrument a number of the advantages of several, and of furnishing, in as small a compass as possible, a means by which the air supply and the ether supply might be under perfect control. The inhaler may be described as follows:

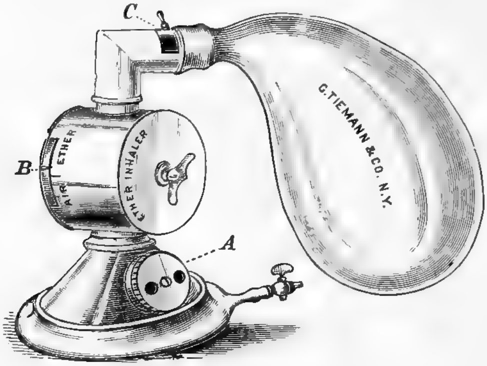

FIG. 1279.—Bennett's Ether Inhaler.

It consists of three parts—the face-piece, the ether chamber, and the bag. The face-piece is cone-shaped; its base is oval and is notched at the nasal end. The apex is open and is threaded to screw into place on the ether chamber. It is of metal, and its free edge is provided with an inflatable rubber cushion, which may be removed at will. On the side of the face-piece is an air tap, *A*, which may be opened or closed to any degree. When fully open, this tap has a large capacity—a desirable feature in a bag inhaler.*

The face-piece is made in three sizes—small, medium, and large. The medium size will be found suitable for all ordinary cases, but small children and large men require special sizes.

The ether chamber, shown in the "sectional view," consists of two cylindrical metallic boxes, one fitting accurately within the other. The inner box presents four openings in its sides, two of which, *k* and opposite, are

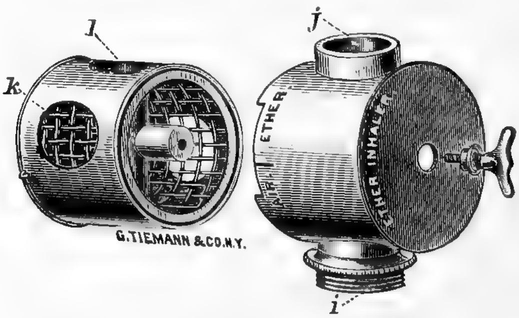

FIG. 1280.—Bennett's Ether Inhaler; Sectional View.

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* In this respect the Ormsby apparatus is usually inadequate, the tap being too small, and in Clover's there is no air tap.

of large size; the other two, *l* and opposite, are smaller and are connected by a tube which passes through the centre of the box. This part of the ether chamber is provided with a cage of coarse wire netting, to hold the gauze which receives the ether. The cage is somewhat smaller than the box it occupies, the intervening space allowing the respired air to circulate freely around the gauze rather than through it, thus offering little or no resistance to respiration. The cage also prevents the gauze packing from protruding through the openings *k* and opposite, and thus interfering with the rotation of the inner chamber. On the closed end of the inner box is placed a revolving disc, presenting a small circular opening at one point near its periphery; this opening is surmounted by a short funnel-shaped chimney, and may be brought opposite any one of three openings in the end of the box. By this arrangement it is possible, when the patient's head is turned on the side, to pour ether upon the gauze without removing the inhaler from the face—a matter of great practical advantage under certain circumstances.* The outer box presents two large and opposite openings in its sides, and each of these is surmounted by a chimney, one of which is threaded to receive the face-piece, the other being smooth and bevelled to receive the bag. On one side of the free edge of this box is a slot, which, in connection with a pin and pointer on the inner chamber, limits the rotation of the latter and indicates whether "air" or "ether" is being breathed. When the two parts of the ether chamber have been put together, they are held in place by the thumb screw shown in the drawing, and this serves the further purpose of a handle for revolving the inner cylinder.

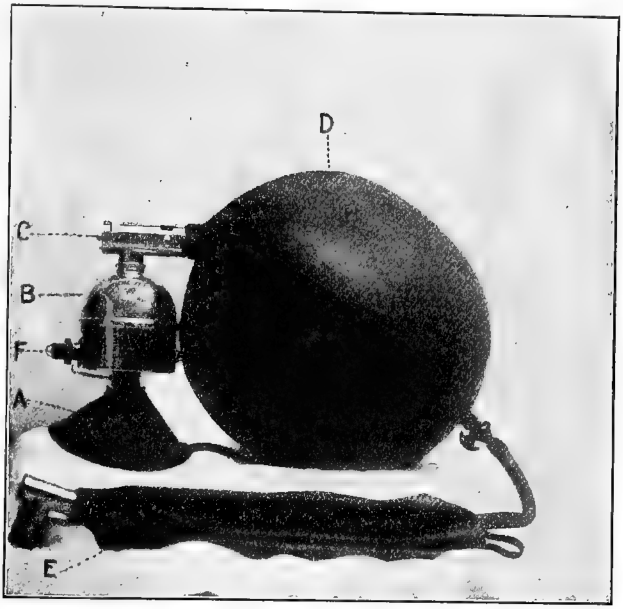

FIG. 1281.—The Clover-Hewitt "Gas and Ether" Inhaler. *A*, Face-piece with inflatable edge; *B*, ether chamber of Clover inhaler (improved); *C*, valve chamber of Hewitt's gas apparatus; *D*, gas bag of Hewitt's gas inhaler; *E*, ether bag of Clover's inhaler; *F*, rubber stopper with hollow glass dome, by which ether may be seen.

By referring to the sectional view of the ether chamber, it will be seen that a tube traverses the centre of the inner cylinder, its upper opening being marked *l*. Now if the two parts are put together in the positions they occupy in the cut, it is evident that the openings of the tube *l* will correspond with those marked *i* and *j* of the outer cylinder; and if breathing should take place through the inhaler so arranged, the air would pass directly through the tube *l* without entering the ether space proper. In this position it will also be noticed that the index pointer, seen directly below *k* in the "sectional view," occupies the lower end of the slot on the outer cylinder, indicating "air." If the inner cylinder is now rotated so that the index traverses toward "ether," it will come to a transverse line between "air" and "ether," and in this position the openings of the tube *l* are just beginning to pass out of the openings *i* and *j*, and the openings *k* and opposite are beginning to enter the openings *i* and *j*. Breathing through the inhaler in this position allows a very small percentage of air to pass through the ether space; further rotation increases this percentage, till finally the tube *l* has passed completely away from the openings *i* and *j*, and full ether is on, the index pointer being at the upper limit. In this way the ether may be turned on as slowly as desired, and any strength of ether vapor may be administered at will throughout the narcosis.

The ether bag is of large size, its capacity exceeding the most exaggerated respiration. It is attached to an elbow of metal tubing, by which it is connected with the upper chimney of the ether chamber when in use. In this elbow, near the attachment of the bag, is a large air tap, *C*, which may be opened to any degree.

The use of the ether inhaler may be briefly described as follows: The wire cage is packed firmly with dry gauze, upon which one-half ounce or more of ether is poured; the index is now turned to "air," the taps *A* and *C* are closed, several expirations are caught to distend the bag, and the face-piece is then kept applied; the index is now turned to the line between "air" and "ether" and is moved forward slowly toward the latter, an occasional breath of air being given by removing the face-piece. Complete anæsthesia is present in from two to five minutes in average patients. The administration now consists chiefly in the regulation of two factors—the ether supply and the air supply.

The ether supply: In continuing the administration, it is best to allow the index to remain at full ether and to pour from one-half to one drachm of ether upon the gauze every two or three minutes as necessary. This may be done (1) through the face-piece, (2) through the chimney, or (3) through the revolving disc on the end of the ether chamber; (1) is preferable in usual cases; (2) or (3) is of great advantage when it is inconvenient to remove the inhaler from the face.

The air supply: During the induction of anæsthesia enough air should be given to prevent more than slight cyanosis. In maintaining anæsthesia it is rarely necessary to exclude air to the extent of causing any cyanosis, and the air supply is to be regulated in accordance with the following facts: The tap *C* being closed, if *A* is opened slightly the patient will receive little air and much ether; if fully opened, he will receive much air and little ether. The tap *A* being closed, if *C* is opened slightly the patient will receive little air and much ether; if fully opened, he will receive much air and much ether.

The quantity of ether necessary in usual cases will average about four ounces for the first hour and about two ounces for the second hour.

Ether Preceded by Nitrous Oxide.—For this excellent succession of anæsthetics we are indebted to Clover, who called attention to it in 1876, and of which Buxton has recently stated, "It is the best method of producing general anæsthesia." The advantages of this succession of anæsthetics may be briefly stated as follows: Great comfort to the patient in being spared all knowledge of the administration of the ether. Great saving of time, complete ether anæsthesia being accomplished in from two to four minutes in average patients. Complete absence of struggling and of the usual phenomena of the stage of excitement.

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* In operations about the head or neck it is often desirable to cover the inhaler and the hand and arm of the anæsthetist with a sterile towel. Under these circumstances it is inconvenient to disarrange this every time it is necessary to add ether, and it was for this class of cases in particular that the arrangement was added. When this plan of adding ether is to be used, the inhaler should be so applied to the face that the revolving disc is uppermost.

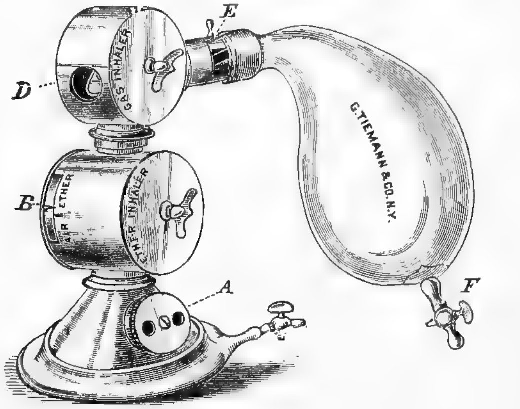

FIG. 1282.—Bennett's "Gas and Ether" Inhaler.

There are two plans of conducting this form of anæsthesia. In one, nitrous oxide is administered to complete anæsthesia, when the gas is stopped and strong ether abruptly substituted and rapidly pushed. This was Clover's original method, but through the advocacy of the plan by Mr. Woodhouse Braine, it has been called his method. Mr. Braine changed from nitrous oxide by an ordinary apparatus to ether in an Ormsby inhaler.

In the other plan, also devised by Clover, a gradual transition from gas to ether takes place, and to do this Clover perfected an excellent inhaler which, however, was large and impracticable for general use. Hewitt, by combining his own nitrous-oxide inhaler with Clover's portable regulating ether inhaler, has produced an excellent "gas and ether" inhaler which is shown in Fig. 1281. A single bag full of gas is sufficient. The gas inhaler fits into the place of the usual bag of the Clover inhaler. Gas is administered through the charged ether inhaler, the index of which points to 0 (no ether). When two-thirds or three-fourths of the gas has been breathed through valves, the latter are thrown out of action by closing the tap at C, whereupon rebreathing of gas takes place. At this time ether is turned on gradually so that both gas and ether are administered. This is continued till signs of complete gas anæthesia appear, when the tap cutting off the gas and admitting air is turned so as to do this. After a few respirations of air and ether the tap is again closed and gas and ether are rebreathed. Ether anæsthesia is soon deep enough to discontinue the gas, and this is done by removing the gas inhaler and substituting the ether bag. Ether is now continued as usual.

The author's inhalers for gas and for ether are made to combine in the same way as the Clover-Hewitt apparatus, and act on the same plan (see Fig. 1282).

Chloroform, A. C. E., ethyl chloride, and ethyl bromide have each been administered before ether with agreeable results, though they are neither as safe nor as pleasant as nitrous oxide for this purpose.

Nitrous Oxide.—There are several different plans of administering this agent—pure, mixed with air, or mixed with oxygen. Nitrous oxide is a true anæsthetic and does not depend upon asphyxia for its narcotizing effect. Administered in a pure state the resulting anæsthesia is *complicated* by asphyxia depending upon deprivation of oxygen. Given in combination with small percentages of air, complete anæsthesia may be induced with marked lessening or absence of asphyxia. In combination with oxygen, complete anæsthesia results without asphyxia. In order to administer nitrous oxide in its pure state it is necessary to employ an apparatus in which, through the action of valves, the inspirations are made to be taken from the gas reservoir and the expirations made to pass out into the surrounding air.

Before gas was supplied in the present portable form a gasometer was an essential part of a nitrous-oxide apparatus, but with the advent of the small cylinders containing liquefied gas and with the perfection of the accurately fitting face-pieces of the present time, the gasometer became unnecessary, though it is still extensively used, especially in dental offices. White's complete gas apparatus with gasometer is shown in Fig. 1283.

The author's gas inhaler (Figs. 1286 and 1287) consists of three parts—the face-piece, the valve chamber, and the gas bag. The face-piece is identical with that of the ether inhaler.

The valve chamber consists of two cylindrical metallic boxes, one fitting accurately within the other. The inner box contains a **T** of tubing, the longer or cross part of which traverses the centre of the chamber and is joined in the middle by the shorter or stem part of the **T**. The three ends of this **T** open upon the outer surface of the sides of the box. The longer of these tubes contains the valves mounted upon a skeleton tube, which may be removed at will. The valves themselves consist of thin rubber flaps, fastened at one end over fenestrated diaphragms set in an inclined position in the skeleton tube. Each rubber flap is reinforced by a thin piece of aluminum cemented to its surface. This keeps the rubber flat and prevents it being forced through the opening which it guards, during violent respiration.* On each side of the opening of the short or stem part of the **T** above described is placed a similar opening communicating with the general box cavity.

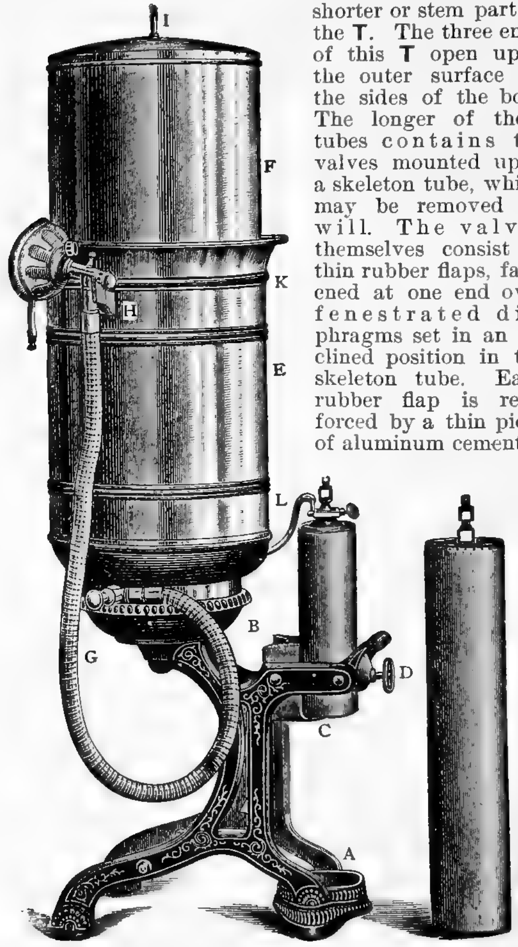

FIG. 1283.—The White Nitrous Oxide Apparatus with Gasometer. Showing end-valve cylinders containing 100 gallons and 450 gallons of liquefied nitrous oxide.

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* These valves may be replaced when necessary by cutting pieces of rubber bandage into proper shape and cementing the aluminum forms to them.

The outer box presents three openings through its sides, two of which are provided with chimneys. One of the latter has a thread cut upon it for the screwing on of the face-piece. The other is slightly bevelled for the twisting on of the gas bag.

The boxes are held together by a thumb-screw, which also serves as a handle for rotating the inner chamber, the rotation being limited by a slot on the outer box and a pin on the inner.

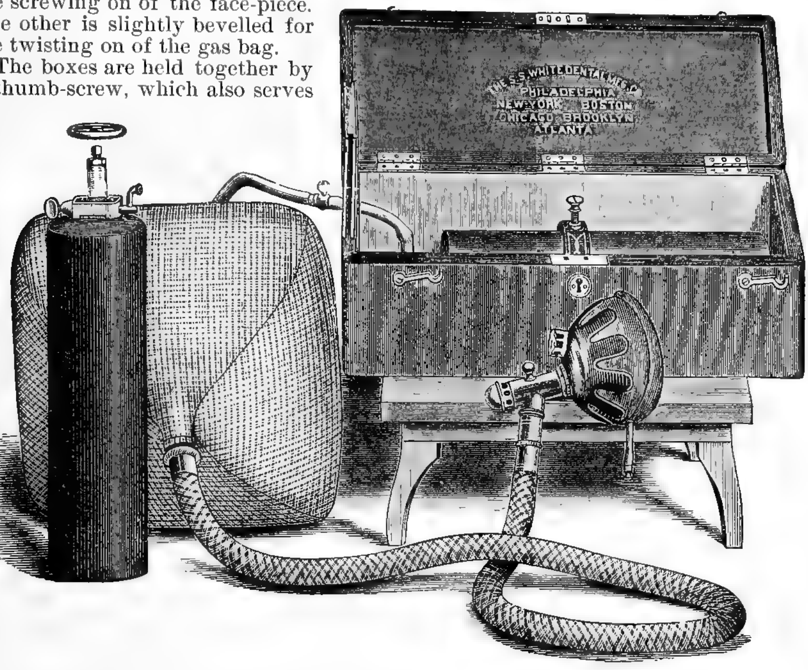

FIG. 1284.—White's Portable Nitrous Oxide Apparatus. Showing cylinder with yoke and wheel key.

The gas bag is of pure rubber, and has a capacity of about two gallons when just full, but will distend to several times this capacity without bursting.* It is attached to a short metal tube, the free end of which is ground to fit the smooth chimney of the valve chamber. In this tube is placed a large air tap, shown at *E* in Fig. 1286, which may be opened or closed by a lever. Working in connection with this air tap is a cut-off, placed between the air tap and the bag, and so arranged that when the air tap is fully open the gas is completely cut off and confined to the bag. When the air tap is closed the bag is opened into the tube. At the opposite end of the gas bag is a hard-rubber stopcock, through which the gas is admitted to the bag. By referring to the sectional view of the gas inhaler, it is apparent that if the two boxes are pushed together in the positions they occupy in the cut, the face-piece screwed on at *a*, and the inhaler breathed through, during inspiration the valve at *d* will close so that the air must enter through the chimney *c*, pass through the valve at the opening *h*, and down through the opening *f* into the face-piece. During expiration the valve at *h* will close and the air must pass into the **T** and out through *d* and *b*, which are now together. The inhaler is used in this position in the ordinary administration of nitrous oxide. By revolving the inner box so that *d* is depressed and *h* elevated to the limit allowed by the pin and slot above referred to, the opening *b* will be closed and *e* and *g* will come together with *a* and *c* respectively. Breathing now takes place through the box cavity, the valves are out of action, and both inspiration and expiration pass through the opening *c*. This position is used for a short time during the administration of "gas and ether."

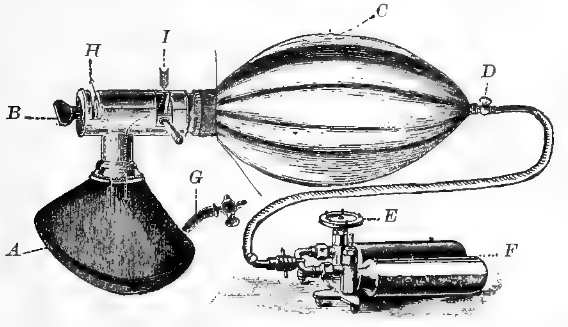

FIG. 1285.—Hewitt's Nitrous Oxide Inhaler. *A*, Rubber face-piece with inflatable edge (through tube *G*); *B*, valve chamber—action of valves indicated by arrows at *H* and *I*; *C*, gas bag of about two gallons capacity; *D*, stopcock for disconnecting a full bag from tube; *E* and *F*, side-valve cylinders with foot-key.

The object of placing the bag close to the face-piece in Hewitt's and the author's inhalers is to avoid the resistance to respiration which is occasionally noticed in breathing through a long tube. This resistance causes a feeling of suffocation in some patients. Gas bags are made of pure rubber or rubber cloth. The former are to be preferred for several reasons. They are less bulky, can be

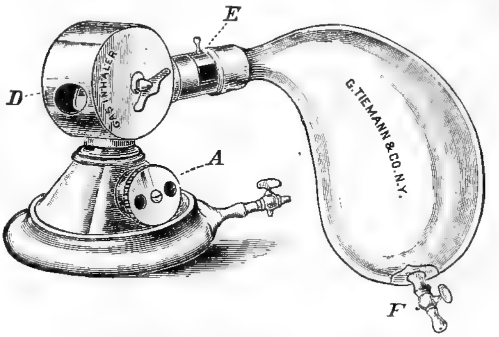

FIG. 1286.—Bennett's Nitrous Oxide Inhaler.

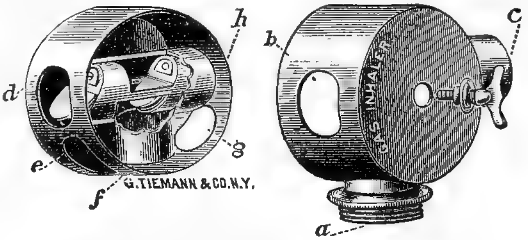

FIG. 1287.—Bennett's Nitrous Oxide Inhaler; Sectional View.

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* A very practical point in view of the fact that such over-distention is common from inability or failure to turn off the gas in time, or from unexpected rushes of gas from the cylinder. Under these circumstances bags made from non-elastic material must burst, and this is a matter of alarm from the loud report, failure of the narcosis from inability to proceed, and expense from having to replace the bag.

thoroughly washed and boiled when necessary, and will distend greatly before bursting.

In Hewitt's and the author's inhalers the valves may be thrown out of action at will, whereupon to-and-fro breathing will occur. This is of service in the administration of "gas and ether," and may occasionally be used in prolonging an administration which would otherwise be cut short owing to the supply of gas unexpectedly giving out.

An administration of pure nitrous oxide may be briefly described as follows: The gasometer or bag having been filled from the cylinder and the face-piece accurately applied, a few respirations without gas are permitted, to accustom the patient to breathing through the valves. Gas is then turned on and breathed by the patient until the signs of complete gas anæsthesia are present. In this form of administration these signs are largely due to the deprivation of oxygen and consist chiefly in cyanosis, stertorous, jerky, respiration, twitching movements in the extremities, rotation and fixation of the eyeballs, dilatation of the pupil, and absence of conjunctival reflex. The time consumed in such an administration has been found by Hewitt to be as follows: Maximum, 70 seconds; minimum, 25 seconds; average, 51 seconds.

The duration of the anæsthesia resulting from such an administration was found by Hewitt to vary between 20 and 65 seconds, with an average of 42.1 seconds. Hewitt later reduced this average to 35 seconds as being nearer correct.

There are two plans of administering gas mixed with air, the difference depending upon the manner in which the air is admitted. In one a small percentage is mixed with the gas throughout the administration, while in the other, breaths of air are given intermittently. A single complete administration of gas and air consumes considerably more time than an administration of gas alone. The resulting anæsthesia is somewhat longer than from gas without air, and there is a marked lessening or absence of cyanosis, twitching movements, jerky respiration, and other asphyxial symptoms. If too much air is mixed with the gas excitement will appear.

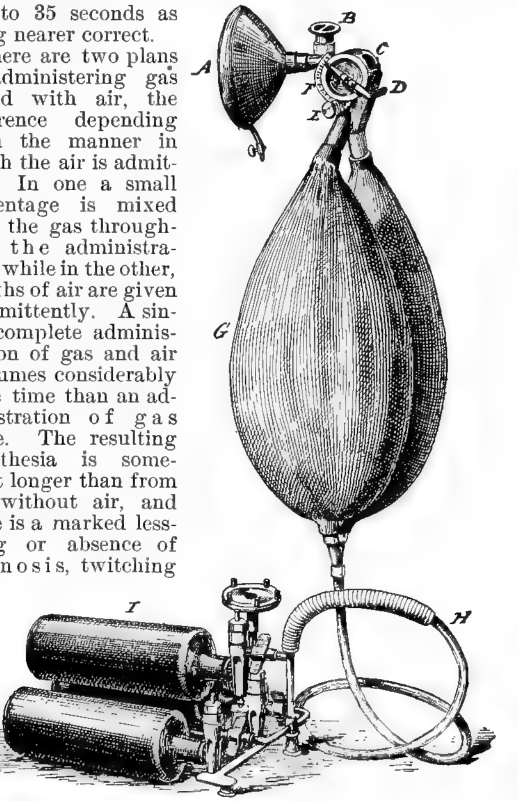

FIG. 1288.—Hewitt's Nitrous Oxide and Oxygen Apparatus. *A*, Face-piece with inflatable edge; *B*, expiratory valve; *C*, air tap for inspiration when the gas is cut off; *D*, lever by which gas and oxygen are turned on; *E*, special stopcock for turning on more oxygen than controlled by lever *D*; *F*, index showing proportion of oxygen from 1 to 10; *G*, double bag, one side for gas, the other for oxygen; *H*, double tube (one within the other); *I*, cylinders of gas and oxygen.

Nitrous oxide with oxygen is most satisfactorily administered under increased atmospheric pressure, as demonstrated by Paul Bert, but in practice this method is impracticable. Under ordinary conditions this combination may be administered in two ways. A definite percentage mixture may be given from an ordinary gas inhaler, or a special apparatus may be employed, by means of which a mixture of any desired proportions may be used.

Hewitt found the most satisfactory definite mixture to contain 12.75 per cent. of oxygen. He obtained better results, however, by means of a regulating inhaler, and the apparatus shown in Fig. 1288 is the outcome of his investigations on this subject during a period of eight years. This apparatus has a regulating mechanism by means of which nitrous oxide may be given pure or plus from 1 up to 30 parts of oxygen.

A typical administration with this apparatus may be described as follows: The bags having been emptied of air and then filled about three-fourths full of their respective gases, the face-piece is applied with the index pointing to air, which the patient now breathes through the inhaler. When it is seen that the face-piece is well applied the index is turned at once to 1 or 2, where two or three respirations are allowed; the index is now moved forward a number at a time, and at each number two or three respirations are permitted. When the index has reached 6 or 8 about a minute has elapsed, as a rule, and there should be signs of moderate anæsthesia, the breathing should be slightly stimulated, the patient quiet, the color good, and the conjunctiva somewhat insensitive. Under these circumstances the inhalation should proceed, moving the index more gradually forward till signs of complete anæsthesia are present. If the oxygen has been turned on too rapidly signs of light narcosis will appear, the breathing will become shallow, there may be excitement, phonation, movement, or retching. In this event the index must either remain stationary till the signs pass off or must be turned back a point or two for a number of breaths and then forward more slowly. When a satisfactory narcosis has been reached the patient's condition is usually as follows: The respiration is slightly stimulated, the pulse is normal or slightly stimulated, the color is normal or slightly flushed, the eyeballs are usually rotated downward and fixed, the conjunctiva is insensitive, and the extremities are relaxed. The narcosis may be continued as long as required, the administration being governed by the principles already mentioned. It will be found that as the inhalation proceeds, a gradual increase in the percentage of oxygen will be necessary. All changes in the proportions of the gases should be made gradually if possible. Sudden changes produce marked effects which are apt to interfere with the smoothness of the narcosis. The bags should be kept about two-thirds full and equally distended throughout the administration.

Gas and oxygen is unquestionably the best and safest form of nitrous-oxide anæsthesia. It possesses all of the favorable characteristics of the latter, and is to a great extent free from the worst of its unfavorable features, *i.e.*, the asphyxial element, to which may be attributed practically all that is dangerous and unpleasant in ordinary nitrous-oxide anæsthesia. The unfavorable characteristics of gas and oxygen are as follows:

1. Difficulties, inconvenience, and expense of the administration.
2. Light form of narcosis.
3. Failure to procure satisfactory anæsthesia, in a small percentage of cases.

1. Gas and oxygen is vastly more difficult to administer satisfactorily than is chloroform or ether, and this is due to the fact that the method presents a great number of technical details which require considerable experience and the closest attention. It is practically impossible to move the patient after this anæsthetic has been started without disturbing the narcosis. It is therefore necessary to have the patient upon the operating-table before beginning, and any other than the supine position renders the administration too difficult to be practicable. The apparatus is large and is apt to be in the way if the operation is about the head or neck. It is necessary to pro-

tect the tubes through which the gases flow from pressure. If stepped upon they will burst, as the author has several times found out. The cost of a long administration of gas and oxygen is considerable compared with ether or chloroform; five dollars' worth of the gases not infrequently being consumed.

2. While the narcosis may be carried to a deeper degree with gas and oxygen than with gas alone, it is occasionally not deep enough, and this is very especially true in reference to rectal and abdominal operations. The abdomen is peculiarly apt to remain rigid, even though the narcosis is deep and free from signs of asphyxia, and gas and oxygen is not to be recommended for intra-abdominal operations, except in cases in which the advantages of this form of anæsthesia more than offset this particular disadvantage.

3. Failure to produce satisfactory anæsthesia is exceedingly rare and is very apt to be the result of faulty administration. The author is convinced, however, that there are patients who, with fairly skilful treatment, will not pass into that quiet, deep narcosis which is desirable. These patients probably belong to the class that take anæsthetics badly, requiring large doses and showing marked resistance to the action of the agent used.

The Choice of Gas with Air or with Oxygen as the Anæsthetic.—The limitations above noted in regard to the scope of nitrous oxide for surgical operations indicate in a way its field of usefulness. In the writer's judgment, however, the greatest indications for the employment of this form of anæsthesia are to be found: 1. In patients who are more than usually endangered by ether or chloroform, by reason of their general physical state or on account of the presence of some special pathological condition. Examples of this class are found in very weak patients, in the very aged, and in those presenting active lesions of the lungs, the kidneys, or the heart. 2. In operations that are so short or so trivial as to render the effects of ether or chloroform out of proportion to the case. 3. In patients who have previously suffered unusually from the effects of ether or chloroform and who have great dread thereof. The following list of cases from the author's personal records may be of interest as indicating the possibilities of this anæsthetic:

Amputations: Arm, for extensive necrosis of hand. Breast, for carcinoma, with removal of the axillary glands. Toe, for gangrene.
Curetting: Uterus, sinuses, abscesses, etc.
Excision: Carbuncles of neck, leg, etc.
Incision: Abscesses of neck, leg, breast, vulvo-vaginal, etc.
Laparatomy: Appendicitis, exploration, ventro-fixation.
Plastic operations of face.
Suprapubic cystotomy for stone.
Many cases of the following: Examinations, painful dressings, suture of wounds, circumcision, ligature of hemorrhoids, anal and vaginal dilatations, breaking up joint adhesions, stretchings in orthopædic cases, etc.

The time of operation in those cases ranged from a few seconds to ninety minutes. The ages of the patients ranged from below one year to eighty-four years.

A single complete administration of gas and oxygen has been found by Hewitt to take an average of 110 seconds and the duration of the resulting anæsthesia to be 44 seconds as an average. The longer or shorter the inhalation of gas alone or in combination with proper amounts of air or oxygen, the longer or shorter the anæsthesia.

DANGERS OF ANÆSTHESIA AND THEIR TREATMENT.—The dangers which result from the administration of anæsthetics are connected with either the circulation or the respiration. The dangers of chloroform are chiefly in connection with the circulation and are manifested by various degrees of circulatory depression. The dangers of ether and nitrous oxide are chiefly in connection with the respiration and are manifested by various degrees of asphyxia. The nature and manner of production of these conditions have been discussed in the article *Anæsthetics* (Vol. I.), under "Physiological Action" and "Phenomena of Anæsthesia," while the class of cases in which they are most likely to occur will be found under "Choice of the Anæsthetic."

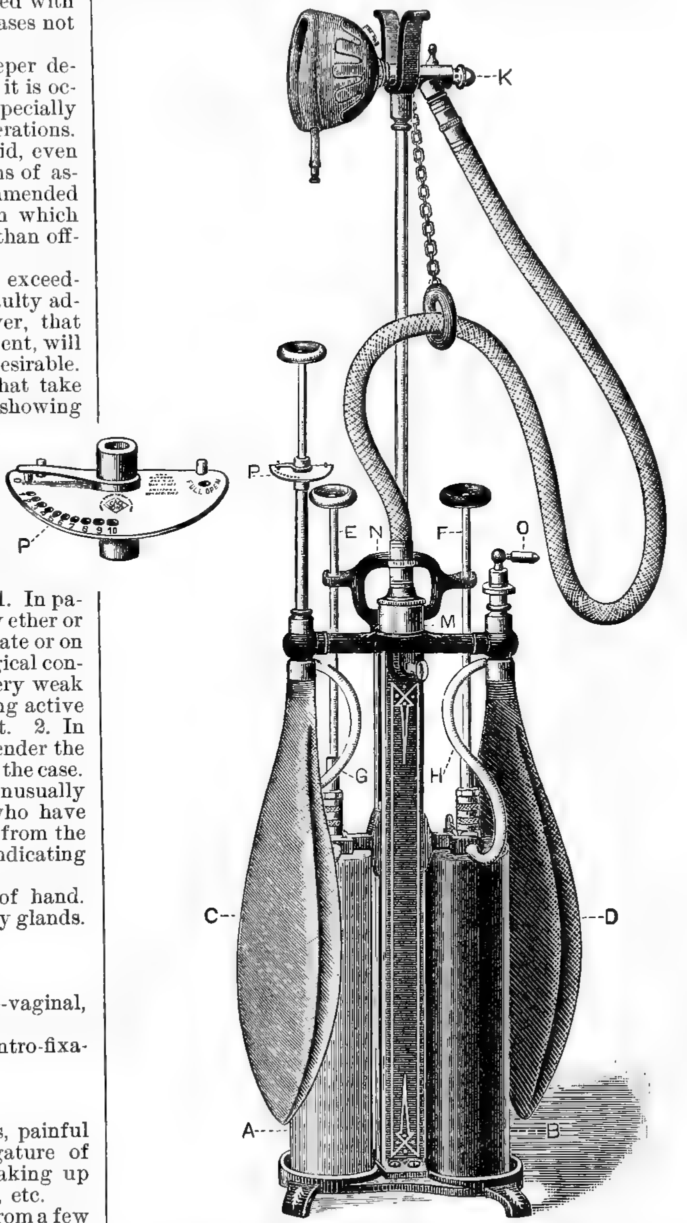

FIG. 1289.—White's Nitrous Oxide and Oxygen Apparatus. A, Red cylinder containing 40 gallons of oxygen; B, black cylinder containing 100 gallons of nitrous oxide; C, oxygen bag; D, nitrous oxide bag; E and F, keys controlling flow of the gases through the tubes G and H; O and P, keys controlling flow of gases to the mixing chamber M and thence to the face-piece K. If O is opened and P closed, pure nitrous oxide will be breathed. If O is closed and P opened fully, pure oxygen will be breathed. Oxygen may be turned on in varying amounts according to the index shown in P *enlarged*.

The various degrees of asphyxia met during the administration of anæsthetics are due, for the most part, to the following causes: *Direct obstruction to respiration,* as caused by stertor, valve-like action of the air passages and orifices above the larynx, and foreign bodies; *spasm of the respiratory muscles; paralysis of the respiratory centre* by an overdose.

The various degrees of circulatory depression met during anæsthesia, which are attributable, directly or indirectly, to the anæsthetic, are due either to too little or to too much of the agent. Too little of the anæsthetic causing incomplete anæsthesia may result in depression of the circulation through nausea and through reflex effects brought about by operative procedures. This is rare under ether, but not uncommon under chloroform.

Circulatory depression from an overdose of the anæsthetic occurs in two ways. If the overdose is administered gradually the dangerous effects upon the circulation are usually secondary and consecutive to dangerous paralysis of the respiration. If the overdose is administered rapidly the circulatory depression is usually primary, especially in the case of chloroform. Unduly prolonged narcosis often causes gradual circulatory depression. The immediate dangers, therefore, in the administration of anæsthetics are manifested by either asphyxia or syncope.

One of the greatest sources of respiratory obstruction during anæsthesia is that associated with *stertor* which may be of nasal, buccal, palatine, pharyngeal, or laryngeal origin. Stertor may be inspiratory or expiratory, and may occur during light or deep anæsthesia. During light anæsthesia it is frequently reflex from operative procedures, while during deep narcosis it is usually paralytic. The direct cause of stertor is the interference of the tissues and organs situated in the air way above the trachea with the currents of air during inspiration and expiration. The situation of the tongue, its weight, and its relations with the epiglottis and larynx, render it perhaps the greatest source of obstruction to respiration during anæsthesia.

In the treatment of these conditions prophylaxis is of the greatest value, for a majority of the difficulties and dangers of anæsthesia are due to faulty administration. Unfortunately, a considerable experience in the administration of anæsthetics is necessary before faulty administration can be corrected.

Reflex stertor, if troublesome and distinctly connected with the operative manipulations, should be met by a deeper narcosis. Stertor not resulting from too light narcosis may be relieved by the following measures: extension of the head by moving the chin away from the sternum; pushing the lower jaw forward by pressure beyond its angles; pulling the tongue forward by the tip or hooking it forward from its base. One or more of these measures will relieve all ordinary obstructions to respiration during anæsthesia; but should they fail and the asphyxia be alarming, tracheotomy should be performed promptly. Obstruction to respiration due to valve-like action of the nares, cheeks, lips, and pharynx should be prevented or relieved by the use of a nasal speculum or by opening the mouth and preventing its closure by a small prop. Obstruction to respiration from foreign bodies, as blood, mucus, stomach contents, or other material, should be met by the prompt removal of same.

An exceedingly rare form of obstruction to respiration during anæsthesia is that due to spasm of the muscles of respiration with absolute cessation of all respiratory movement. This usually occurs in the early stages of narcosis during the period of general muscular rigidity. All that can be done in such cases is to see that the air way is free and then perform vigorous artificial respiration. All forms of obstructed breathing resulting in asphyxia, with cessation or practical cessation of respiration, should be treated by performing artificial respiration after determining the unobstructed condition of the air way. The administration of oxygen during this time would seem to be indicated in hastening the relief of the asphyxia. Asphyxia from paralysis of the respiration by an overdose of the anæsthetic is to be treated on the lines already referred to. In all cases of asphyxia the heart should be sustained by the administration of stimulants, which will be referred to under "syncope."

The best methods of performing artificial respiration for the purpose under consideration are: simple compressions of the chest, Silvester's method, and forced respiration.

Forcible compression of the chest and its subsequent expansion not only creates a considerable movement of air in the lungs, but is a powerful excitant of respiratory effort, if the patient's condition renders such response possible. Air expelled from the lungs in this way also serves to relieve obstructions, such as firm apposition of the epiglottis to the laryngeal opening, foreign bodies, etc.

Silvester's method of artificial respiration is more readily carried out and more effectual than other similar methods. Faradism of the phrenic nerves is a decided aid to artificial respiration. Forced respiration by means of the Fell-O'Dwyer or similar apparatus would probably be of great value in extreme cases of asphyxia of this nature if it could always be at hand and ready for use.

The manner in which syncope is produced through the action of the anæsthetic has been considered in the first part of this article under "action on the circulation." The syncope which occasionally occurs from nausea and from operative procedures under light narcosis by chloroform should be avoided by not permitting the conditions which allow it to occur.

The minor degrees of circulatory depression occurring under chloroform may be relieved by lessening the administration if the narcosis is of moderate or deep degree, or by changing to ether or A. C. E. and by the administration of restorative measures to be considered later.

Alarming degrees of syncope call for prompt and energetic treatment. The administration should be stopped and nothing allowed to interfere or delay the application of restorative measures. The condition of the circulation and respiration should be carefully noted. The anæsthetic contained in the air of the patient's lungs should be removed by rapid and effective artificial respiration, and throughout the subsequent treatment of the case the air way should be maintained in an unobstructed condition. In the treatment of the graver forms of syncope the following are the chief measures of value:

Posture.—More or less inversion of the patient (Nélaton's plan) is almost invariably practised under these circumstances, and there can be no doubt that many lives have been saved through this means. The improvement in the pulse and respiration following inversion in *approaching* collapse from chloroform is proof of its value under these circumstances. It is supposed to act by determining a flow of blood to the medulla and to the heart, thus stimulating respiration and circulation. Inversion has been employed, however, in nearly all of the fatal chloroform accidents, and it is thus evident that it is not invariably effective; indeed, it is probable that it is often positively harmful.

In sudden complete syncope we have seen that the heart is paralyzed and distended with blood, as are the great vessels of the chest and abdomen. Hill has pointed out that to invert a patient under these circumstances is "worse than useless," as "the paralytic dilatation of the heart is thereby increased." Hill recommends the following measures which he has found to relieve nearly every case of this kind in animals. "Artificial respiration is at once applied, the thorax is rhythmically squeezed over the region of the heart, while the animal is placed in the horizontal position. If the pulse does not speedily return the animal is dropped into the vertical, feet-down posture. By this simple means the heart, owing to the influence of gravity, is emptied into the splanchnic area, and thus the dilatation of the organ is relieved. Artificial respiration is maintained throughout this manœuvre. After a few seconds the animal is returned to the horizontal posture, and the heart is thus filled with a fresh supply of blood. If the pulse does not return, the manœuvre is once more repeated. When the pulse has returned and the heart beat has become efficient, the artificial respiration can be discontinued, and after a short space of time the natural breathing will usually return, owing to the excitation of asphyxia. During this period the pulse must be carefully watched, and artificial respiration renewed if there be any signs of failure. . . . The second type of collapse (slow and gradual overdose) is relieved by the vertical head-down position (Nélaton's method). It is equally relieved by the horizontal position and artificial respiration. As the anæsthetist can never be sure which type of collapse he has to deal with, it seems to me that Nélaton's method should never be employed. If we have to deal with the first type of collapse (sudden overdose) Nélaton's inversion is a fatal mistake; if the second type of collapse confronts us, recovery can be brought about by performing artificial respiration and placing the patient in the horizontal position."

Artificial respiration carried out by rhythmic compressions of the thorax, by Silvester's method, by methods of forced respiration, and by faradism of the phrenic nerves, probably affords the most effective means of treating syncope from anæsthetics.

The method of *heart compression*, commonly referred to as the method of Koenig or the Maas method, has proved to be of great value in many cases of chloroform syncope. The following description is that of Maas: "The operator stands on the left side of the patient with face toward the head of the patient; the cardiac region is pressed upon with rapid and strong pressure by the ball of the right thumb laid upon the chest between the place of apex beat and the left border of the sternum; one-hundred and twenty shocks or compressions are to be made per minute. Care must be taken to exert enough force. Fix the patient's body by the left hand on the right side of the thorax. Success is denoted by artificially produced carotid pulse and contraction of pupils, which should control the force and rapidity of impulses. An assistant should watch the pupil and carotid pulse. As long as the condition of the patient does not improve the pauses in treatment should be as far between and as short as possible. When the pupil contracts you may wait till it begins to dilate, or as long as spontaneous respiratory movements continue."

Drugs.—The experiments of Wood have demonstrated the great value of strychnine and digitalis in the treatment of syncope from chloroform, and the inefficiency of alcohol, atropine, ammonia, amyl nitrite, and caffeine in this condition.

Strychnine must be used in large doses under these circumstances. The author has given as much as gr. $\frac{3}{20}$ in divided doses with advantage upon several occasions, and others have given still more.

The experiments of Schäfer and others prove that suprarenal extract acts as a powerful vaso-motor stimulant, and, as an antidote to the depressant effect of chloroform, it is highly recommended.

The striking effect of the rectal, subcutaneous, or intravenous injection of saline solution in conditions of shock and collapse is proof of its value in syncope from anæsthetics. Laborde's method of "tongue traction" has been resorted to in many cases of apparent death from anæsthetics with excellent results. The tongue, being grasped by the tip, is pulled forward over the teeth as far out of the mouth as possible; it is then permitted to spring back into the mouth. This is repeated at about the normal respiratory rate till respiration is re-established. Success has been attained after long-continued and apparently hopeless effort.

Briskly rubbing the lips often excites increased respiratory efforts, and in the light breathing which occurs early in an overdose this may be used with advantage. Faradism of the heart and puncture of that organ with a needle have been recommended in chloroform syncope, but are of doubtful value.

The following valuable analysis of chloroform fatalities is taken from Hewitt on anæsthetics:

AN ANALYSIS OF 210 CHLOROFORM FATALITIES (= 109 COLLECTED BY THE COMMITTEE OF THE ROYAL MEDICAL AND CHIRURGICAL SOCIETY, AND 101 COLLECTED BY KAPPELER).

(*a*) *Sex.*

Males	150
Females	59
Not stated	1
	210

(*b*) *Age.*

Under 5 years	2
6–15 years	21
16–30 "	49
31–45 "	53
46–60 "	37
Over 60 years	3
Not stated	45
	210

(*c*) *Nature of Operation.*

Amputations	36
Dislocations	16
Removal of tumors	17
Examinations of injuries (including putting up of fractures)	9
Operations on male genito-urinary organs	20
Operations on anus, rectum, etc	11
Operations on female genital organs	5
Operations on eye	16
Hernia	3
Castration	4
For necrosis, excision of bone, etc	7
Excision of joints	2
Forcible straightening of joints	7
For application of escharotics	8
Plastic operations	6
Ligature of arteries	1
Opening abscesses and sinuses	7
Impaction of fæces	1
For removal of teeth	18
Removal of toe-nail	5
For relief of neuralgia	2
For delirium tremens	2
For maniacal excitement	1
Not stated	6
	210

(*d*) *Period of Inhalation at which Death Occurred.*

Under one minute	10
One to three minutes	13
Three to five minutes	12
Six to fifteen minutes	33
Over fifteen minutes	7
Not stated	135
	210

(*e*) *Stage of Anæsthesia at which Death Occurred.*

Commencing to inhale	14
Stage of excitement	30
Incomplete anæsthesia	49
Fully under influence	68
After operation	31
Not stated	18
	210
Or, Before full effects of chloroform	93
During full effects	68
After operation	31
Not stated	18
	210

(*f*) *Mode of Death.*

It is best, perhaps, to keep the two analyses under this heading separate.

Royal Medical and Chirurgical Committee.

"Syncope	56
Syncope during stage of excitement	6
Died suddenly	6
Died in a fit	10
Pulse and respiration ceased together	9
Failure of respiration (pulse not noted)	6
Failure of respiration (pulse remaining)	2
Not stated	14
	109"

Kappeler.

Group 1. Imperfectly recorded cases, or cases in which death could not be ascribed directly to chloroform	61
Group 2. Fully reported cases in which death occurred as the immediate result of chloroform	40
	101

Analysis of Group 2.

A. Death with primary evidences of circulatory failure (14 fully under and 9 partially under chloroform)	23
B. Cases in which respiration ceased first (10 fully under and 7 partially under chloroform)	17
	40

(*g*) *Mode of Inhalation.*

On handkerchief, towel, napkin, or lint	87
Lint with sponge	5
On sponge	11
With an ether inhaler	2
Snow's inhaler	5

An inhaler	23
Paper bag or cloth cone	3
Skinner's mask	2
A mask	1
Esmarch's mask	5
Metal inhaler with plenty of air	2
Clover's apparatus	5
Not stated	59
	210

After-Effects.—The following is a brief account of some of the chief conditions which have been called the after-effects of anæsthetics.

Nausea and vomiting constitute the most conspicuous and distressing, though not the most dangerous of the consequences of anæsthesia. Nitrous oxide causes the least after-disturbance of this kind; and while ether causes nausea and vomiting more frequently than chloroform, more cases of protracted and dangerous vomiting are met after chloroform than after ether.

Patients differ greatly in respect to this effect, and a patient may vomit excessively on one occasion and little or none on another under apparently like conditions.

Patients properly prepared for the administration have less sickness, as a rule, than those not so prepared, although in many instances a case presenting a full stomach and no preparation will not be nauseated after anæsthesia.

Washing out the stomach at the close of the administration will lessen or prevent nausea and vomiting in a large percentage of cases, and is an excellent routine practice if carefully done.

At later periods this is also one of the best means of treatment, and after consciousness has been restored it may be carried out at proper intervals by allowing the patient to drink a glass of warm water and expel it by vomiting. A large dose of the bromide of sodium or potassium by way of the rectum will often act beneficially in this condition, and the administration of opium is occasionally the only means that will control it.

Headache following anæsthetics, commonly seen after prolonged administration of nitrous oxide, may be best relieved by cold applications to the head, bromides, or opiates.

Bronchitis, broncho-pneumonia, and typical lobar pneumonia have occurred with noticeable frequency after anæsthetics. These conditions are observed after all anæsthetics, but more commonly after ether than after chloroform. They are probably not due to the direct effect of the anæsthetics upon the pulmonary tissues, but are caused, for the most part, by infections of the lungs through material aspirated into them from the throat during the narcosis, such material often carrying pneumococci and other bacteria derived from the throat and nose. Add to this the chilling influences attending the anæsthesia and the operation, the repression of coughing after certain operations, and the exposure incident to change from the operating room, change of clothing, etc., and it is not surprising that these pulmonary after-effects occasionally develop.

The treatment of these conditions is the same as though they occurred under other circumstances. Prophylaxis consists chiefly in the use of clean inhalers, cleansing the mouth, nose, and throat before the administration, avoiding the aspiration of foreign material into the air passages, keeping the patient from exposure and depression.

Renal congestion, nephritis, and urinary suppression are not infrequently observed after the administration of anæsthetics, as referred to under "Physiological Action." The effects of the deprivation of fluids before and after operation, exposure, and sepsis must not be overlooked in this connection. Treatment should be carried out on usual lines. Saline infusion by way of the rectum, cellular tissue, or veins has proved of great benefit in promoting kidney action under these conditions.

Jaundice, glycosuria, insanity, and other abnormal states have been noted after anæsthetics have been administered. Their exact relations to the narcosis are not fully understood.

After-Care.—During the recovery of patients from the effects of anæsthetics they should have certain special care made necessary by their condition. They should receive assistance during the vomiting which may follow, and, owing to the suddenness with which this may occur, the patient should never be left alone till he is quite capable of taking conscious care of himself. Vomiting is most easily and safely accomplished if the patient is on the side, and this position should be assumed if possible. If the dorsal position is necessary, the head should be turned well to the side during vomiting and elevation of one shoulder will help the position. Large particles of vomited matter should be removed from the mouth as quickly as possible. The common custom of pushing the jaw forward during vomiting is unnecessary and dangerous. It defeats the effort of the patient to protect his air passages.

The patient must be guarded from exposure during recovery. The chilling influences of the anæsthetic and the operation render the patient unusually sensitive, and more than usual covering should be provided. Artificial heat should be used if necessary, but in its application it should be remembered that the patient is more or less anæsthetic and may not notice the presence of a hot-water bag or bottle that is burning him. This is a frequent and disastrous accident. The patient should not be exposed to draughts. Undue sweating should be avoided.

The question of food and drink is important. The custom of withholding everything for many hours is unnecessary. The patient's desire for food or drink is often a reliable guide for the beginning of the same. Weak patients should not be kept as long as others without nourishment. As a rule, it seems best to begin with rather small quantities of warm fluids, proceeding according to the particular conditions present. Thirst may often be relieved by the combination of large amounts of fluid by the rectum and small amounts by the mouth.

Thomas L. Bennett.

[As this article is going to press the "report of the Anæsthetics Committee of the British Medical Association" is announced. It comprises a careful and minute study in great detail of 25,920 cases from reliable sources. The following conclusions, taken from the *Lancet*, London, are thought to be justified:

CONCLUSIONS.

Relative Safety of the Various Anæsthetics.—1. The relative safety of the various anæsthetics may be gathered from the statistical tables in the report. When only those cases of danger which were held to be due entirely to the anæsthetic are considered the following instructive figures are obtained, further emphasizing the danger of chloroform as contrasted with ether. Cases of danger (including deaths) considered to be due entirely to the anæsthetic: under chloroform, 78, giving a danger rate of .582 per cent.; under the A. C. E. mixture, 1, giving a danger rate of .147 per cent.; under mixtures of chloroform and ether, 2, giving a danger rate of .478 per cent.; under the A. C. E. mixture followed by chloroform, 1, giving a danger rate of 1.694 per cent.; under chloroform preceded by ether, 5, giving a danger rate of 2.2 per cent.; under chloroform followed by mixtures of alcohol, chloroform, and ether, 1, giving a danger rate of .36 per cent.; under ether, 2, giving a danger rate of .065 per cent.; under "gas and ether," 3, giving a danger rate of .096 per cent.; under ether preceded by chloroform, 1, giving a danger rate of .480 per cent.; under ether preceded by the A. C. E. mixture, 0; under the chloroform group of anæsthetics (addition of the first six headings above), 88, giving a danger rate of .584 per cent.; and under the ether group of anæsthetics (addition of the last four headings above), 6, giving a danger rate of .085 per cent. 2. Although (excluding nitrous oxide) ether may be accepted as the safest routine agent, certain circumstances determined by the state of the patient, the nature of the operation, etc., may render the use of some other anæsthetic or combination of anæsthetics both safer and easier.

The Best Methods of Administration.—3. No method of administration of chloroform is free from danger, but an examination of the complicated cases appears to show that the occurrence of danger depends largely upon the administrator who employs any particular method. 4. No conclusion from the evidence before the committee as to the best method of administration of ether and "gas and ether" is possible. 5. The data warrant the conclusion that the A. C. E. mixture should not be given from a closed inhaler—*e.g.*, Clover's. This conclusion applies to all mixtures containing chloroform.

Best Methods of Restoration.—7. The sub-committee are unable from the material at their disposal to draw any conclusion upon this point.

Clinical Evidence Regarding Anæsthetics Generally.—8. Anæsthetics are more commonly associated with complications and dangers in males than in females. 9. Excluding infancy, and taking anæsthetics collectively, the complications and dangers of anæsthesia increase *pari passu* with advancing age. 10. Anæsthetics are notably more dangerous in proportion as the gravity of the patient's state increases. 11. Danger to life is especially likely to be incurred at early periods of the administration of anæsthetics, while the tendency to less grave complications increases directly with the duration of anæsthesia. 12. The tendency for complications, dangerous and otherwise, to occur increases *pari passu* with the gravity of the operation.

Clinical Evidence Regarding Chloroform.—13. Chloroform is about twice as dangerous in males as in females. 14. Chloroform is most dangerous during early infancy and after thirty years of age; least so from ten to thirty years of age. 15. In conditions of good health chloroform is very much more dangerous than other anæsthetics. In grave conditions chloroform still remains the least safe anæsthetic, but the disparity between it and other anæsthetics is far less marked than in health. 16. When danger occurs under chloroform, whatever its exact nature may be, there is abundant evidence that in a large proportion of cases the symptoms that are observed are those of primary circulatory failure. 17. Imperfect anæsthesia is the cause of a large number of cases of danger under chloroform. 18. Vomiting during anæsthesia, which may lead to danger, seems to be more frequent under chloroform than under other anæsthetics. 19. Struggling is very much more frequent in the complicated cases under chloroform than in the uncomplicated, and this phenomenon must therefore be regarded as a source of grave danger under chloroform. 20. The tendency for circulatory complications to appear increases directly with the relative amount of chloroform n the anæsthetic employed. 21. While vomiting is more common after administrations of ether, severe and prolonged vomiting is more common when chloroform has been used. 22. Circulatory depression following anæsthetics is more common after chloroform than after ether. 23. While the respiratory complications of anæsthesia as a whole are of equal frequency under the ether and chloroform groups respectively, yet those that occur under ether are mostly of a trifling and transitory nature while those that occur under chloroform are more grave and persistent.

Clinical Evidence Regarding Ether.—24. Under ether the complications of anæsthesia are more frequent with males than with females, but with the former they are generally slight, ether being rather more dangerous with females than with males. 25. Ether, where employed throughout or preceded by nitrous oxide gas or by the A. C. E. mixture, is singularly free from danger in healthy patients. 26. Minor troubles in administration due to laryngeal irritation and increased secretion are more common under ether and "gas and ether" than under chloroform and its mixtures. 27. Struggling occurs more frequently with ether when given alone than with other anæsthetics, but it rarely leads to danger. 28. After-vomiting is more common with ether than with other anæsthetics, but it is usually transient. 29. Bronchitis is much more common as an after-effect of ether than of chloroform. 30. With "gas and ether," as with ether, dangers are more common in females, although complications are more frequent in males.

Clinical Evidence Regarding Mixtures and Successions of Anæsthetics.—31. The A. C. E. mixture in most of the statistical tables holds an intermediate position between chloroform and ether. 32. The A. C. E. mixture is more dangerous in males than in females, but not to such a marked degree as is chloroform. 33. The administration of ether antecedent to chloroform does not abolish the possibility of chloroform dangers. 34. The various mixtures and successions of anæsthetics were recorded too infrequently to justify definite conclusions.

General Conclusion.—35. From the evidence before the sub-committee they are convinced that by far the most important factor in the safe administration of anæsthetics is the experience which has been acquired by the administrator. In many cases the anæsthetization completely transcends the operation in gravity and importance, and to insure success, particularly in these cases, it is absolutely essential that an anæsthetist of large experience should conduct the administration.]

CHLOROL is a disinfectant and deodorizer consisting of an aqueous solution of one per cent. each of bichloride of mercury, sodium chloride, and hydrochloric acid, and three per cent. of copper sulphate. *W. A. Bastedo.*

CHLOROMA.—*Cancer vert.* A tumor belonging to the general class of sarcoma, more precisely to the group of lymphoma, lymphosarcoma, so-called leukæmic and pseudo-leukæmic tumors, etc. The name was given by King, of Glasgow, in 1853, and indicates the remarkable color of the new growth, which is usually a bright green. Chloroma is remarkable for the frequency with which it affects the periosteum of the cranium, especially in the orbital and temporal regions and in the dura. Various other parts of the periosteum are also frequently affected, besides the lymph glands, bone marrow, liver, kidneys, spleen, lungs, pleura, and other organs. In some cases the tumors have first been discovered in peripheral organs such as the mammary gland or the axillary lymphatic glands, but even in such cases it is probable that the primary growth is in the periosteum of the cranium. The new growth has a tendency to invade the connective tissue, involving fasciæ, tendons, etc., and sometimes forms very extensive infiltrations. In structure the tumor consists of a fine reticulum in which cells of the size and character of lymphocytes lie, traversed by bands of connective tissue continuous with that of the seat. The consistence varies from very soft to very hard, depending chiefly on the connective tissue. The cause of the green color is not known. According to some it is a fat pigment; others compare it to the pigment of green pus. Chloroma occurs especially in early life, although a number of cases have been observed in middle life. More cases have been observed in males than in females. Clinically, chloroma is characterized by rapidly increasing anæmia with petechiæ, nose-bleed, and sometimes scorbutic symptoms; by loss of weight, fever, headache, deafness, tinnitus aurium, blindness and double vision, and by facial paralysis and exophthalmus. Many cases have been first seen in eye or ear clinics, on account of the special symptoms mentioned, and it is possible that in some cases not examined anatomically the disease has been mistaken for an ordinary orbital sarcoma. In a number of cases increase of leucocytes has been observed, the increase affecting especially mononuclear cells having the general character of lymphocytes, the appearance of the blood in other respect closely resembling that in cases of so-called acute leukæmia. The course of the disease is rapid and progressive. The changes in the blood and the structure of the tumors have led a number of observers to assign chloroma to the group of diseases including leukæmia, pseudoleukæmia, certain cases of lymphosarcoma, and some of the tumors described as myeloma. Ignorance of the etiology of all of these processes makes a definite opinion impossible at this time. The idea of bacterial infection is very strong, but positive proof is as yet absent. Chloroma should be recognized in most cases comparatively early on account of the striking combination of symptoms, especially from the coexistence of anæmia with or without increase of lymphocytes, the characteristic new growths in the orbital and temporal region, the ear symptoms and others mentioned above.

Most of the observations on chloroma are referred to in articles of Dock, *American Journal of the Medical Sciences*, August, 1893, and Lang, G., *Archives générales de Médecine*, November *et seq.*, 1893, and July–September, 1898.

George Dock.

CHLOROSIS.—Chlorosis is a term applied to a specific form of anæmia which occurs in young women about puberty and which is often characterized by a greenish-yellow tint of the skin, whence the derivation of the name χλωρος, yellowish green.

Notwithstanding the great progress, in recent years, in our knowledge of disorders of the blood and of the changes, particularly in its corpuscular elements, characteristic of different diseases, the position of chlorosis as an independent malady has been in no way affected, and it still remains quite distinct from all other anæmias. Thus every other form of anæmia is found in both sexes, but the occurrence of true chlorosis in males is now generally denied. Chlorosis, therefore, occurring only in women, and limited in them to the time of life connected with the development of their sexual function, shows that this disease is somehow conditioned by that function. This primary fact should dispose of several hypotheses which have been advanced both as to its etiology and its pathology. Thus Sir Andrew Clark's theory that it is caused by auto-intoxication from retained fæcal accumulation leaves unexplained why it never happens to constipated men, and Virchow's theory that it is due to congenital hypoplasia of the arterial system is negatived by the occurrence of too small arteries, including the aorta, in both sexes. The inference, therefore, seems clear that chlorosis is in some way related to the function of ovulation, and the problem is to find what that relation is.

At present the examination of the blood itself is the first requisite in determining the nature of any form of anæmia, and it is because the changes in chlorosis are so constant in their contrast with other cases of blood impoverishment that its specific nature is so plainly demonstrated. Thus in all febrile anæmias, as in tuberculosis, rheumatism, etc., the whole blood becomes impoverished, both the corpuscles and the blood plasma being diminished. In chlorosis, while the corpuscles may be diminished in number (though very commonly this is much less than the paleness of the patient would suggest), yet the proteids of the plasma, as a rule, are increased, a feature peculiar to chlorosis. This fact also serves to distinguish chlorosis from the anæmia caused by loss of blood, for in the latter the serum is more watery and the specific gravity of the plasma is low, while in chlorosis, different from all other anæmias, the specific gravity of the plasma is high and often higher than normal. In the secondary anæmia of parenchymatous nephritis, the presence of anasarca and of albuminuria suffices to clear the diagnosis. More uncertainty might arise in some cases of inanition in young women suffering from gastric ulcer, especially as dyspepsia and gastric pains are common among chlorotics; but the palpable signs of gastritis with pain after eating and the occurrence of hæmatemesis are distinctive in these cases, while the examination of the blood does not show the specific deficiency of hæmoglobin in the red corpuscles characteristic of chlorosis, nor is the chlorotic hue present in the complexion. Some leucocytosis is also commonly present, while in chlorosis it is absent.

From the sallow anæmia of some forms of chronic hepatic disease, as a sequel to chronic malaria, chlorosis may be distinguished by the conjunctiva being quite clear instead of yellowish; there is no enlargement of the liver, nor do we find the rough, parchment-like condition of the skin, with movable folds, which distinguishes hepatic marasmus, as the skin in chlorotics is of silky smoothness and well rounded or plump. In active malaria the presence of the plasmodium malariæ decides the diagnosis. From leukæmia, which in the absence of emaciation often resembles chlorosis, the great excess of white corpuscles at once reveals the difference, as leucocytosis does not occur in chlorosis, nor does enlargement of the lymphatic glands. From that comparatively rare and fatal disease, true splenic anæmia, which occurs without either involvement of the lymphatic glands or leucocytosis, the diagnosis is easy by reason of the great enlargement of the spleen in that disease, while it is wholly absent in chlorosis. From pernicious anæmia, in which disease the common occurrence of a lemon-yellow hue of the skin might be mistaken for the tint of chlorosis, the examination of the blood shows the greatest contrasts. Not only is the diminution of the red corpuscles far greater than in chlorosis, but poikilocytosis or irregularity in the shape and size of the corpuscles is characteristic; megaloblasts and microblasts and nucleated red corpuscles along with the myelocytes are found, all of which are absent or extremely rare in chlorosis. The most distinctive difference, however, is that which exists between chlorosis and pernicious anæmia. In the latter disease the percentage of hæmoglobin in the individual corpuscles, especially the smaller forms, is very high, some of them having a brilliant red color, while deficiency of hæmoglobin in the red cells is the distinctive feature of chlorosis. In the anæmia of malignant disease the blood also shows poikilocytosis, but otherwise the cancerous cachexia with its sallow, muddy skin and general emaciation would suffice to distinguish it from chlorosis, apart from the fact that the latter is a disease of youth, at which period of life cancer is rare.

In other words, the blood of chlorotics is deficient in its oxygen-carrier, hæmoglobin, and scarcely deficient in anything else. The red cells may equal in number those found in women in fair health, but they are pale and the percentage of hæmoglobin may fall from one hundred to sixty-five, or forty per cent., or even lower. A loss of breathing power necessarily follows, with results, as regards the muscular function, which adequately explain the chief clinical symptoms of the disease.

Chlorosis is markedly hereditary, mothers of young women with it often stating that they were similarly affected when at their daughters' age. Different from many secondary anæmias, it is as often found among the well-to-do classes as among the poor or poorly fed. Among European races, at least, it is pretty equally distributed, being as common in Italy as in England or in America. The element of age, however, is significant. A first attack after twenty-five is almost unknown, and if it does occur then or later it is a relapse from a former attack. Chlorosis may occur before menstruation, but the commonest period is in the quinquennial between fifteen and twenty.

Symptoms.—Muscular power in all animals is directly proportioned to the activity of respiration, that is, to the intake of oxygen. As it is the hæmoglobin in our blood which enables us to breathe, a deficiency of that element will have for its first sign breathlessness. This symptom, therefore, is one of the earliest and most constant in chlorosis. Mural weakness of the heart, at first dynamical and later intrinsic from fatty degeneration, is a natural consequence of deficiency of oxygen, and hence these patients are prone to palpitation on exertion and to attacks of syncope. The muscular apparatus of the alimentary canal also suffers, and atony with passive dilatation of the stomach, and the same condition in the intestinal canal, give rise to the dyspepsia and constipation with borborygmi which characterize a majority of these patients. Easy exhaustion and fatigue of the skeletal muscles is evidenced by the general sense of languor and lassitude on the one hand, and by a great variety of spinal aches on the other, the commonest localities being, as we might expect, at the nape of the neck, where the weight of the head is felt, and in the lumbar region, where the whole weight most tells on the spinal column in standing or walking. As in all cases in which deficient muscular power fails to keep the vertebræ in their normal position, reflected neuralgias from pressure on the spinal roots are very common. They appear in the form of headaches, pains in the eyes, intercostal pains, and others referred to various points in the abdominal walls.

The chlorotic hue is absent in about forty per cent. of all cases, whether blondes or brunettes. The examination of the blood shows what a mistake it is to suppose that the disease necessarily shows itself in the tint of the skin. Some clear-complexioned blondes and likewise brunettes show nothing but simple paleness as an habitual state, with faces also that readily heighten in color on excitement. Nowhere, however, is the evidence of anæmia so sure as on the backs of the hands, and next to that on the ears. The chlorotic hue, however, may not be specially noticeable about the face, and yet be readily noted on baring the chest. In typical cases the discoloration is very characteristic, especially about the lower folds of the skin of the face, but that it is in no sense jaundice is revealed by the pale caruncle of the eye, the transparent conjunctiva, the blue sclerotic, and the anæmic mucous membranes of the mouth. No theory as to the cause of the chlorotic discoloration has yet seemed to me satisfactory.

As to special symptoms, the pupils are often dilated and so sluggish as occasionally to impart the same staring expression which is of such unfavorable import in renal disease. An annoying dry cough is sometimes quite persistent, especially at night, or coming on in excited conversation. It is probably connected with the functional dyspnœa of the disease and is best relieved by improving the blood and not by cough medicines, though it is often temporarily allayed by ten or fifteen grains of ammonium bromide with a teaspoonful of aromatic spirits of ammonia. The pulse presents some peculiarities. Different from other anæmias (except that due to kidney disease), the pulse of chlorotics often shows considerable tension. The difference in this respect from all febrile anæmias, or from that following loss of blood, or in pernicious anæmia, is quite pronounced. This tension may be due to the full volume of the circulating fluid along with capillary retardation from lessened activity of oxygenation in the tissues. An indication that capillary interchange is slow in chlorosis is found in the general puffiness of the face and extremities with a tendency to œdema of the ankles.

In no other anæmia is the venous hum so loud in the jugulars, particularly the right, as in chlorosis, its loudness being increased on standing and by light pressure upon the vein with the stethoscope. It is a markedly vibratory sound, and the vibration of the vein can often be felt by the finger laid upon it. It varies capriciously from time to time, and as it has little diagnostic or prognostic value, we will not enter upon the difficult question of the mechanism of its production.

Vibration of the arteries so that they are seen to throb also happens occasionally in chlorosis, with now and then a systolic murmur in them, especially in the left subclavian, where it might be mistaken for aneurism. Such arterial murmurs may be due to laxity of the vessels from irregular vaso-motor tone of their muscular coats, as in Graves' disease.

The condition of the heart calls for more consideration. The old term 'irritable' well expresses its usual state, for it is easily excited by physical exertion or by emotion. The impulse is diffused and weak, while the first and second valvular sounds are not merely loud but there is less difference between them in quality than is normal. Sometimes the second sound is louder at the apex than at the base. There is often a striking similarity in these sounds to those observable in cardiac dilatation, and that they may be due to analogous conditions is not improbable, for mural softening with temporary distensibility occurs both in anæmia and as a result of poisoning by the rheumatic toxin.

On the other hand, systolic functional cardiac murmurs are often present in chlorosis. In about seventy-five per cent. they are most pronounced in the pulmonary area and are transmitted to the left. They often distinctly increase in intensity on lying down and diminish on standing up, or increase when the patient is turned on the right side and again lessen when he is turned on the left. Holding the breath also may diminish them, while they become louder with the succeeding deep inspiration. Organic murmurs, on the contrary, are rarely heard in the pulmonary area and are not much affected by changes of position except in some cases of mitral stenosis. A systolic cardiac murmur may be suspected to be functional in character when its point of greatest intensity is found in an unusual place for an organic murmur. Thus, as just remarked, organic murmurs in the pulmonary area are very rare, just where functional murmurs are common. But I have also found the junction of the left fourth rib with the sternum a frequent site for these sounds, and in several cases they were heard at the junction with the right fourth rib. True mitral systolic apex murmurs are also found in chlorosis, and of the same soft blowing character as that observed in the transient mitral murmurs which develop in some cases of rheumatic fever. Ludwig and MacAlister have shown that the auriculo-ventricular muscular structures have a sphincter-like action, whose narrowing of the mitral orifice greatly helps the valves to close it. Any cause, therefore, which produces softening of the cardiac muscle, as the rheumatic toxin does, or as may also happen in consequence of the degenerative effect of anæmia, would then allow insufficiency to occur without the valves being necessarily diseased; and hence with a restoration of the heart wall to its normal vigor these murmurs would disappear. It should always be feared, however, that an undue overtaxation of the heart at such times might cause this curable condition to pass into permanent organic change.

PATHOLOGY.—The pathology of this affection is still a matter of discussion and of diverse views. Pathological anatomy supplies but few data because patients rarely die from the affection. Rokitansky's and Virchow's findings of general arterial hypoplasia in cases of this disease must be regarded as chiefly coincidences, because the great majority of chlorotics recover after proper treatment, which would not be possible if they were all the subjects of congenital malformation. Iron pills can hardly cure an aorta if it be too small, nor does this theory begin to explain why such a condition should diminish hæmoglobin only and not either the leucocytes or the albumen, and lastly why too small arteries should be thus operative only in females. Many writers, from Andrew Clarke down, incline to the operation of some specific toxin in the blood as the cause of the impoverishment of the corpuscles. As other forms of anæmia are increasingly ascribed to toxæmia it is natural to infer the same for chlorosis. The primary difficulty of this hypothesis is that it affords no explanation why chlorosis should occur only about or just after puberty, and it does not easily appear why such special toxin should be formed in the gastro-intestinal tract or elsewhere of young women only and not in older women as well. That the supposed toxæmia is of intestinal origin is negatived by the observations of numerous investigators that neither indican nor the ethereal sulphates are in excess in chlorotic patients. The urine is simply deficient in solids, but contains no excess of iron, as in pernicious anæmia, nor of urobilin.

I incline rather to the view that the constitutional state accompanying the first establishment of ovulation is characterized by a special vulnerability to certain injurious influences which it takes time to outgrow. That the innervation and functions of the associated blood-making viscera in the abdomen are readily disturbed in women by influences propagated from the generative organs is shown often enough at the beginning of pregnancy when vomiting so induced may be severe enough to threaten life. The first onset of menstruation is not without its counterparts to the first disorders of pregnancy, and as the derangements progress in either case we have often the same curious perversions of the appetite, like the cravings for wholly abnormal articles. The gastric troubles of pregnancy are explained by reflex irritation from the ovarian and uterine plexuses, but just such reflex irritation may occur from deranged menstruation.

Menstruation can be arrested by putting the feet in cold water, with great risk, however, of inducing the most pronounced and obstinate disorders of the functions and secretions of the entire gastro-intestinal tract. This irritation of cold, occurring under circumstances favorable for this effect, *i.e.*, while the ovaries are excited by the process of ovulation, may produce a persistent vaso-motor contraction of the arteries of the pelvic viscera first, and of other abdominal organs in succession, which effect is quite similar to that sometimes caused by a puncture or mechanical irritation of a nerve of the arm or of the leg, such as the musculo-spiral or anterior tibial, and which may radiate to all the arteries of the limb and produce tonic contraction of its muscles with coldness and wasting.

A remarkable case, published by me in the Transactions of the State Medical Society of New York for 1867, illustrates very fully how extensive and curious the effects may be of such a reflex irritation from cold during menstruation. The case was that of a girl who got a wetting during a cold thunder shower while she had her courses. They were immediately arrested, but she took no notice of any effect therefrom until she became so constipated that she passed a week without an evacuation. She was obliged then to admit that this was the case to her teacher at school, because of the excessively loud borborygmi which were heard by all in the classroom. Two physicians were called in consultation, who, finding they were unable to cause a movement, and stercoraceous vomiting having set in, summoned Dr. White, of Buffalo, late professor of obstetrics in the Bellevue Medical College of New York. He diagnosed intestinal obstruction, and advised a course of treatment which produced a number of free movements, which were remarkable for the almost total absence of any color, the fæcal lumps resembling coarse plaster. On my seeing the case and recommending a free use of nitromuriatic acid, some copious "bilious" discharges followed, and hopes of recovery were entertained, when the same constipation and stercoraceous vomiting returned, along with a singular and very different train of symptoms. Her urine was suddenly suppressed one morning, but in twenty-four hours the saliva and tears welled out to the extent of from one to three pints a day. This continued for about a week with total suppression of urine meantime, when it suddenly ceased and the urine commenced as before; and this strange alternation of secretion reoccurred again and again about every week, for *two months*, with alternate arrest of the bowel movements to be followed by fæcal vomiting, until the death of the patient occurred from sheer exhaustion. This instructive case at least proves that a shock of cold proceeding from the feet may not only arrest the menses by reflex irritation but may also proceed to the production of virtual obstruction of the intestines by paralysis, and then continue to spread from one sympathetic ganglion to another, until the entire association of secretory nerves becomes deranged in turn, and the whole process of alimentation perverted.

It is quite conceivable, therefore, that until menstruation is thoroughly established, many young girls may have an undue susceptibility to sudden chill, particularly of the feet, whose vaso-motor nerves are in such close association with the pelvic circulation that the impression of cold made upon them checks, while heat promotes, the menstrual flow. The sudden derangement of menstruation thus induced by cold might then be propagated, as the first effects of pregnancy are propagated, until serious disorder of the gastro-intestinal secretions intervenes, with consequent impoverishment of the blood. Clinically it is very frequently found that long antecedent to the development of the special symptoms, chlorotic girls have suffered from coldness of the feet, often with muscular pains in the lower extremities indicative of a pelvic vasomotor irritation. It may be objected to this view that although amenorrhœa is the rule with chlorotics, yet some have a normal flow in amount or even more than normal; but, even with these cases, the function becomes in time very irregular and ultimately is suppressed.

TREATMENT.—Iron is the specific for chlorosis, and its remarkable curative effect in this complaint is doubtless the reason why iron is prescribed for every form of anæmia under the impression that it must act as a simple restorative when the blood becomes deficient in red corpuscles. The problem, however, is not so simple as it seems, for iron is actually mischievous in all febrile anæmias and of no avail in many grave forms that are not febrile. Moreover, in chlorosis the best results are secured by giving iron in large and not in small doses, in fact, in doses which are far larger than the corpuscles can possibly take up. Its presence in the intestinal canal seems to act as a stimulus to the assimilation of a normal quantity of iron to restore the deficient hæmoglobin, and clinically it makes but little difference what the preparation of the drug is. Certainly the elaborate forms advertised as closer imitations of nature's own processes for taking up iron do not prove in practice to have any superiority over the common and much cheaper ferruginous salts. After repeated and careful comparative observations with different preparations, I am convinced that the sulphate of iron given in pill form in doses of from gr. iv. to vii., three times a day, is more effective than most other preparations, not excepting Blaud's pills. A bi-weekly action on the bowels with aloes and rhubarb seems to hasten the assimilation of the iron, and in all cases characterized by intestinal flatulence it is a good plan to give gr. x. of sodium benzoate with gr. v. of salicin in capsules an hour after meals. *William H. Thomson.*

CHLOR-SALOL.—$C_6H_4(OH)CO,OC_6H_4Cl$—Chlorophenol salicylate, salicylic-chlorophenol-ester. By the action of phosphorus pentachloride on a mixture of ortho- and para-chlorophenol, crystals are formed of the ortho- and para-salicylic-esters, differing from salol in containing an atom of chlorine in place of an atom of hydrogen. Both are insoluble in water and soluble in alcohol, the former melting at 55° C. (131° F.) and the latter at 72° C. (161.6° F.).

Nencki found that they split up in the intestines into a salicylic acid relative and chlorophenol, and that salicyluric acid appeared in the urine. Girard speaks highly of them as intestinal antiseptics in diarrhœa and cystitis. Passerini obtained good results in bronchitis and pulmonary tuberculosis from the inhalation of fifteen drops once or twice a day for five to ten minutes. The first effect is said to be irritative, but after a day or two the cough begins to lessen and the secretion to diminish. The dose by mouth is 0.33–1 gm. (gr. v.–xv.) three to six times a day. *W. A. Bastedo.*

CHOCOLATE. See *Cacao, Butter of.*

CHOLÆMIA. See *Auto-Intoxication.*

CHOLAGOGUES.—This term is applied to medicines that increase the secretion of bile. It has been in use for more than two thousand years. The ancients observed, after the administration of certain purgatives, that the fæces became markedly yellow or dark. They supposed this change of color to be due to an increased secretion of bile, and hence distinguished the purgatives producing it from others by the term cholagogues.

Until the middle of the nineteenth century clinical experience afforded the only evidence of the existence of cholagogues. The color of the fæces was held to be a certain criterion of the quantity of bile excreted: dark-colored stools indicating redundancy, light-colored ones deficiency of bile. Medicines that produce highly colored dejections, it was supposed, notably augment the secretion of bile. But the researches of physiological chemists have given little support to this theory. While it was found in experiments on animals upon which biliary fistulæ had been made, and in observations on patients with accidental biliary fistulæ, that a considerable quantity of bile is secreted in twenty-four hours, only very small quantities could be detected in the fæces. Bidder and Schmidt[1] estimated the quantity of bile in the fæces passed by a dog in five days, and detected only about one-eighth of the amount of the bile acids that had been secreted. Hence it was evident that the greater part of the bile acids—in the dog seven-eighths—is reabsorbed. Besides, it was shown by Frerichs[2] that the solid constituents of the bile, especially the pigments, suffer great changes in the intestine. These may vary much in health as well as in disease, depending upon the length of time the bile sojourns in the intestines, the kind of food eaten, the medicines taken, and other unknown conditions. Hence it followed that the color of the fæces affords no certain clue to the quantity of bile secreted. It became extremely doubtful, therefore, whether the medicines that produce highly colored stools have any influence on the biliary function.

Nor have the numerous experiments made in the last half-century to determine the influence of medicines on the biliary function fully dispelled this doubt. Nearly all investigators found that the medicines to which an eminent cholagogue action had been attributed, especially calomel and other mercurials, are destitute of the power of increasing the biliary secretion. And in regard to those medicines that have gained celebrity in the treatment of diseases of the bile passages, especially the alkalies and alkaline mineral waters, the results of experimental researches have been so discrepant and mostly so negative that some of the best authorities deny that their utility is due to a stimulant action on the biliary function. Indeed, no other subject in the domain of pharmacology and therapeutics is in so unsettled a condition as that of cholagogues, and some recent competent writers aver that nearly all of the experiments on animals which seemed to demonstrate that numerous medicines increase the secretion of bile were made under such faulty or abnormal conditions as to be utterly valueless.

It seems proper, therefore, to consider in detail only those reputed cholagogues that are of recognized value in diseases of the liver and bile passages, and to adduce the experimental evidence pertaining to their cholagogue action only in so far as it may be conducive to a better understanding of their practical application.

Bile.—According to recent researches, bile itself is the mightiest cholagogue. Its power to increase the secretion of bile has been known for three decades. Schiff[3] observed, when he injected bile into the duodenum of an animal upon which a biliary fistula had been established, that in twelve or fifteen minutes a very decided flow of bile took place from the fistula. In a dog with a biliary fistula, the amount of bile secreted was about 2 c.c. in twenty minutes. The injection of 180 c.c. of fresh ox bile into the duodenum was followed by a surprising increase of the amount of bile, so that after a short time 10 c.c. of bile could be collected from the fistula in twenty minutes. An analysis of the bile showed that the solids as well as the water were increased.

Prevost and Binet[4] investigated the action of numerous drugs on the secretion of bile in dogs with biliary fistulæ. Among those that markedly augmented the flow of bile from the fistulæ, bile itself had the most pronounced effect.

Doubtless the most important experiments demonstrating the action of bile on the liver are those of Pfaff and Balch,[5] made on a woman who had a biliary fistula after the operation of cholecystotomy. The quantity of bile this patient ordinarily secreted in one hour varied from 8 to 42 c.c. Sometimes the maximum was shortly before, sometimes shortly after meals. The secretion, though very irregular, generally increased after meals and during the day, and lessened during the night, reaching the minimum early in the morning. The amount secreted in twenty-four hours, estimated for three days, was nearly constant, varying only from 501 to 525 c.c.

In order to administer the patient's bile, it was evaporated and formed into pills with glycerin, so that each pill corresponded to 25 c.c. of bile. After three pills, given in one day, the amount of bile secreted in twenty-four hours was 546 c.c.; after twelve pills, 600 c.c., and after twenty pills, 685 c.c. The solids of the bile increased from 1.7 per cent. to 2.04 per cent.

Ox gall dried to a powder and made up into pills with glycerin, each containing 0.5 gm. ox gall, had a more notable effect, twenty pills, given during a day, increasing the bile secreted in twenty-four hours to 770 c.c.; and increasing the solids of the bile from 1.69 to 2.62 per cent.

A mixture of pure salts of glycocholic and taurocholic acids was given in pills, each containing 0.25 gm. of bile salts. Two pills, given in a day, increased the bile to 701 c.c.; and eleven pills, given in a day, increased the bile secreted in twenty-four hours to 787 c.c., and the solids to 2.18 per cent.

Pfaff and Balch recommend, in cases indicating cholagogues, inspissated ox gall in pills each containing 0.25 gm., two to five pills to be taken three times a day. They suppose that bile may sometimes be useful in constipation and in cases of defective absorption of fat.

Stadelmann[6] is of the opinion that for therapeutic purposes the bile acids deserve consideration, because they are thrown out unchanged with the bile and sometimes increase the water of the bile as much as eighty to ninety per cent. Besides, the salts of the bile acids are the best solvents of cholesterin; hence they may be employed to dissolve concretions in the gall bladder and to promote the absorption of fat when it is defective in consequence of scanty secretion of bile. The presence of icterus contraindicates their use, because the toxic action of the bile acids might result in slowing of the pulse and destruction of the red blood corpuscles. Sodium glycocholate has been found to be ten times less poisonous than is sodium taurocholate; hence for therapeutic purposes inspissated ox bile, which contains chiefly the former, is an appropriate preparation. Gall stones, however, do not usually consist of pure cholesterin, but of layers of lime salts alternating with cholesterin; hence bile or bile salts will rarely dissolve them.

Gautier[7] states that he has frequently used ox gall with success in cholelithiasis. He began its use in 1891 in the case of a woman who for a number of years had suffered severely from so-called gastralgia. After a very severe attack, which was followed by slight icterus and the passage of numerous gall stones, Gautier had recourse to a decolorized and sterilized extract of ox gall, each decigram of which corresponded to about 1 gm. of gall. This was given in pills containing 0.1 gm. The patient took one or two of the pills during meals for several years. The attacks of colic ceased. Gautier holds that ox gall will not dissolve gall stones nor prevent their painful passage through the bile ducts, but that it will prevent the formation of fresh concretions, and a relapse after surgical removal of the calculi.

Sodium Salicylate.—This medicine has been much employed in various febrile affections, and as a specific in acute rheumatism, since first recommended by C. E. Buss[8] in 1875. Although large doses were administered, no effects were observed that could be attributed to an increased secretion of bile. The credit of the discovery of its cholagogue action belongs to Rutherford.[9] Having found experimentally that the benzoates increase the secretion of bile, he supposed, from the near chemical alliance of salicylic and benzoic acids, and from the fact that both combine in the body with glycocoll, that sodium salicylate would exert some effect on the secretion of bile. A series of experiments on fasting dogs with temporary biliary fistulæ gave a positive result. Within half an hour after the sodium salicylate, dissolved in water, was injected into the duodenum, a marked increase of the bile flow ensued. The dose administered was small, in one experiment gr. xxv., in all the other experiments gr. xx.

The researches of Lewaschew[10] confirmed the results obtained by Rutherford. This experimenter made his observations on fasting dogs with permanent biliary fistulæ, but in all instances he gave the drug internally in gelatin capsules. He found that the quantity of bile secreted became greatly increased within an hour after the administration of 0.5 gm. Such small doses sometimes, though very rarely, failed to augment the bile flow, which never occurred when the dose exceeded 1 gm. Larger doses than 2 gm. did not produce a corresponding increase, the maximum effect resulting from doses of 1.5 to 2 gm., and continuing for more than twenty-four hours. Lewaschew found the solids increased, but the water much more, so that the bile was very fluid.

Prevost and Binet (*loc. cit.*) also confirmed the results obtained by Rutherford, noticing a very decided increase of the biliary secretion in dogs after the administration of sodium salicylate. And since then all experimenters have found this salt to be a very powerful cholagogue.

Körte[11] observed the action of sodium salicylate on two patients with complete (that is, with occluded common bile duct), and on several with simple biliary fistulæ. He states that, after doses of 2 or 3 gm. of sodium salicylate, dissolved in water, he noticed a decided increase of the secretion of bile. His observations are very important, since they prove that sodium salicylate acts upon the liver of man in the same manner as it has been found to act on that of the dog.

From the experiments on dogs and Körte's observations on patients with biliary fistulæ, we may infer that doses of 0.5 to 2 gm. will produce a very marked flow of watery bile in affections of the bile ducts that may be benefited by such an increase of the biliary function. Numerous reports made within the last decade have shown that such small doses proved efficient. Thus Fürbringer[12] stated that he had obtained good effects from sodium salicylate in cholelithiasis. In one case four times, in another five times, both women, gall stones were discharged on the day after administering the salt. As a rule, he gives the medicine in doses of 0.5 gm. with an equal quantity of sodium bicarbonate, four times a day.

Stiller[13] reported, in 1890, that he had used sodium salicylate for five years, and regarded it as a powerful cholagogue. In cases of gall stones he gave 0.5 gm. four times a day, generally with 0.01 gm. of extract of belladonna.

In biliary colic Strisower[14] at first gave two doses of antipyrin, each 0.6 gm., at an hour's interval, and afterward sodium salicylate, 0.6 gm., three or four times a day. The attacks became less frequent and soon ceased entirely.

In a discussion on cholagogues in the *Berliner medicinische Gesellschaft*, Senator[15] stated that he had obtained good results from the use of sodium salicylate, especially when given in combination with extract of belladonna. Ewald claimed to have obtained undoubted success in cholelithiasis from sodium salicylate.

Naunyn's[16] experience with sodium salicylate was also favorable. He repeatedly gave 2 or 3 gm. with success in the beginning of attacks of biliary colic. While Stadelmann[17] fully agrees with other investigators as to the power of sodium salicylate to increase the biliary function, he having observed in experiments after giving 2 to 3 gm. a very marked increase of the bile flow, he dissents from all of them as to the utility of this cholagogue action in catarrhal icterus and in cholelithiasis. He holds that all cholagogues are worse than useless when the ductus choledochus is occluded, because the bile is secreted under very low pressure, and cannot in any circumstances overcome a higher pressure than 120 to 220 mm.

Sodium Bicarbonate.—It has long been observed that mineral waters containing a notable amount of this salt are of decided utility in catarrhal icterus, in hyperæmia of the liver from dietetic excesses, and in cholelithiasis. Frerichs[18] entertained the opinion that alkaline mineral waters, especially Carlsbad, Vichy, and others, produce a copious secretion of alkaline bile, and that such bile exerts a solvent effect upon cholesterin, mucus, and lime salts. Ewald[19] also attributed to the alkaline mineral waters the property of increasing the secretion of bile, and rendering it more watery and alkaline. Murchison[20] held that the undoubted utility of alkaline mineral waters and alkalies in cases of gall stones is due to improvement of the general health, reduction of hepatic congestion, and such alterations of the bile as prevent the formation of fresh concretions. Semmola and Gioffredi[21] say that alkalies have a well-deserved reputation in the treatment of hepatic disorders, not because of a purgative or cholagogue action, but because they act upon the hepatic cell, upon the circulation of the liver, and upon the composition of the bile in such a way as to restore the normal functional powers of the hepatic gland.

The eminent writers on diseases of the liver and bile passages referred to based their opinions chiefly on clinical observations. These had indeed conclusively proved the utility of alkalies in affections of the bile passages, but not that they act by rendering the bile more watery and alkaline. Nor do the recent experimental researches on the physiological action of alkalies upon the biliary secretion sustain this view. Stadelmann,[22] after investigating the action of alkalies upon the biliary secretion of dogs and finding that they do not increase the alkalinity of the bile, surmises that their favorable influence in cholelithiasis is probably due to inspissation of the bile, which, in more concentrated form, may be capable of dissolving gall stones.

Experiments to elucidate the influence of sodium bicarbonate upon the secretion of bile have been made by numerous investigators. The only one that found a decided increase of bile was Lewaschew. He made a series of experiments on fasting dogs with permanent biliary fistulæ. One gram or less did not alter the bile in either quantity or consistency, but larger doses notably increased it in quantity for several hours, and rendered it more watery, the maximum effect resulting from 4 gm. The change in the composition of the bile occurred when the dry salt was administered in gelatin capsules, but was more pronounced when it was given dissolved in a large amount of water.

Glass,[23] a pupil of Stadelmann, experimented on dogs to determine whether the salts of sodium, dissolved in a large amount of water and given internally, render the bile more alkaline. Other pupils of Stadelmann had previously found in experiments that neither water in large quantities nor alkalies increase the bile flow in dogs with permanent biliary fistulæ. All the conditions necessary to obtain trustworthy results were observed in the experimentation: the animals were in good health, and were well fed with a fixed diet; the bile was measured every two hours, and the observations continued for twelve hours. Glass summarizes the results of his experiments as follows:

1. Alkalies taken *per os* do not enter the bile.
2. The alkalinity of the bile is not augmented by the ingestion of alkalies.
3. The relative proportion of the sodium and potassium salts in the bile is constant.
4. A cholagogue action of the sodium salts is not perceptible.

The last conclusion, it seems to the writer, does not follow from the details of the experiments. In five experiments, in each of which the dog received 5 gm. of sodium bicarbonate in 500 c.c. of water, the average of the quantity of bile secreted in twelve hours was 11.5 per cent. greater than in previously made control experiments. In three experiments in which the dog received 10 gm. of sodium bicarbonate in 500 c.c. of water, the average increase was 4.2 per cent. In four experiments in which 15 gm. of the salt were given in the same quantity of water, the average increase in the amount of bile was 1.3 per cent. In four experiments in which 25 gm.

of the salt were given in the same amount of water, a diminution of the biliary secretion amounting to two per cent. took place. Upon this diminution of the secretion of bile by large doses of sodium bicarbonate, Stadelmann seems to base his supposition that the favorable influence of this salt in cholelithiasis is due to inspissation of the bile.

Sodium Sulphate.—This salt is the principal constituent of certain alkaline mineral waters, as those of Carlsbad and Marienbad, long celebrated in diseases of the liver and bile passages. It is the well-known purgative called Glauber's salt, which, on account of its nauseous taste, is now rarely used.

The influence of sodium sulphate upon the biliary secretion of dogs was found by Rutherford and Vignal to be a slight increase; so also by Prevost and Binet. Glass could find no change either in the amount or in the composition of the bile. But Lewaschew observed that 4 gm. markedly augmented the secretion of bile, especially increasing the water.

Lewaschew investigated also the action of the following mineral waters: Carlsbad, Vichy, and Essentuck. All rapidly increased the flow of bile, augmenting both solids and fluids, but the latter more. The effects of the different mineral waters were nearly the same, and hence Lewaschew concluded that they act upon the liver with equal energy.

The results obtained in experiments upon dogs by different investigators as to the action of sodium bicarbonate and sulphate and the alkaline mineral waters are remarkably contradictory and may create some doubt as to their utility. It should hardly be necessary to remind the reader that the utility of the sodium salts has been established beyond doubt by innumerable clinical observations, and cannot be shaken or made doubtful by negative experiments on dogs. When experiments on human beings have been made in sufficient number, the true solution of their mode of action, whether by an increase of secretion or by inspissation of the bile or otherwise, will become clear. Thus far only one surgeon has utilized the opportunity of observing the action of Carlsbad salt upon his patients. Körte (*loc. cit.*) gave this salt to two patients with complete and to several with incomplete biliary fistulæ. The dose was one teaspoonful dissolved in one-fourth litre of warm water. A decided increase in the amount of bile from the fistulæ was observed.

Sodium Phosphate.—This salt is held by some pharmacologists to be a useful cholagogue. Its action upon the biliary secretion was investigated by Rutherford and Vignal in one experiment. They observed a decided increase of the flow of bile, with diminution of its consistency. Lewaschew, in a series of experiments, confirmed this result. Four grams, both in the dry form and in solution, produced a very marked augmentation of the bile flow, and rendered the bile more watery. Doses of 1 gm. and less had no effect, while larger doses than 4 gm. did not cause a corresponding increase. He concluded that sodium phosphate acts as powerfully upon the biliary secretion as do sodium bicarbonate and sulphate, and that all of these salts produce the maximum effect upon the bile flow of dogs in doses of 4 gm.

Sodium Benzoate.—Rutherford and Dods (*loc. cit.*) found that this salt rapidly and decidedly increased the bile flow from biliary fistulæ in dogs. Prevost and Binet, in their experiments, also observed a very pronounced cholagogue action. It greatly resembles sodium salicylate in its behavior in the body, and may be given in the same doses, from 0.5 to 2 gm. several times a day.

Olive Oil.—Olive oil has been used for many years to relieve the pain incident to the passage of gall stones. Dunglison[24] quotes a case in which olive oil was taken to allay severe pains in the stomach which were ascribed to the passage of gall stones. It caused the discharge of masses of fatty matter of globular form varying in size from that of a small pea to that of a moderate grape. Flint[25] relates that a patient who consulted him, having suffered much from the passage of gall stones, at one time took, for a number of days, a pint or more of olive oil daily, at the suggestion of some one who assured him that in this way he had gotten rid of a large number of stones without pain. The patient stated that, under the use of this remedy, he discharged from the bowels an immense number of small, hard bodies, which were supposed to be biliary calculi. Flint held these bodies to be composed of a concrete form of fatty matter.

Rosenberg[26] says that, although the masses of concrete fatty matter were mistaken for gall stones, the use of olive oil was often speedily followed by a subsidence of the intense pain attending the passage of biliary calculi. He refers to twenty-one cases, three in his own practice, in nineteen of which the administration of large doses of olive oil was followed either by improvement or by complete cure. In a series of experiments on a dog with a permanent biliary fistula, Rosenberg found large doses of olive oil to cause regularly a marked increase of the biliary secretion, and he says that the influence of the oil upon the hepatic activity was greater than that of bile and of salicylate of sodium. He supposes that the calculi are forced out of the bile passages by the rapid influx of a large quantity of bile, and when they are not driven out, the pressure of the bile so changes their position that the symptoms of impaction cease and the bile finds its way into the bowel.

The committee of the therapeutic section of the Philadelphia Polyclinic Medical Society[27] appointed to investigate the results of the treatment of gall stones (hepatic colic) with olive oil, reported that records of fifty-four cases had been received; of these cases two had died, and three were not benefited; in all the other cases, ninety-eight per cent., positive relief was afforded. The beneficial effects appeared to be produced chiefly by the increased secretion of bile, and not by a solvent action of the oil on the biliary concretions.

Schulz,[28] in a case of pseudo-hepatic colic due to obstruction of the outflow of bile by carcinoma of the liver, observed that olive oil decidedly increased the secretion of bile, evidenced by aggravation of the colicky pains and great distention of the gall bladder; calomel, on the contrary, did not increase the pain and did not distend the gall bladder.

Troitzky[29] observed a case in which there was a fistulous communication between the gall bladder and the exterior. He found that, when he gave olive oil, the secretion of bile became more abundant. He supposes that, in cases of gall stones in which the administration of olive oil appears to be of benefit, the extra quantity of bile raises the pressure behind the calculi, and thus forces them onward, this action being aided by increased peristaltic movements of the bile ducts.

It is difficult to reconcile the above evidence supporting the view that the favorable action of olive oil in biliary colic is due to an increase of the secretion of bile with the opinion of Stadelmann,[30] that cholagogues cannot possibly be of service when there are obstacles in the bile passages, because increased secretion of bile is not attended by augmented bile pressure. Senator,[31] contrary to Stadelmann, holds that in partial obstruction of the bile passages it is quite possible for an increase of the bile pressure to take place and to overcome obstacles. Doubtless he bases his opinion on the fact that he had often obtained favorable results from olive oil.

Podophyllin.—A cholagogue action was attributed to this purgative because frequently the stools that it produces have a dark color. It had been observed also that, when the motions are white or clayey, moderate doses often speedily restore the normal color to the evacuations. Murchison held podophyllin to be a good substitute for mercury when from any cause this is contraindicated.

Anstie investigated the physiological action of podophyllin on dogs and cats. He found that occasionally bile was poured out in large quantities. This he attributed not to a direct action on the liver, but to irritation of the mucous membrane of the small intestine. Experiments on dogs with biliary fistulæ were made by the Edinburgh Committee[32] and by Rutherford and Vignal. The committee found that podophyllin diminished the secretion of bile. Large doses were administered and free purgation resulted, which doubtless, as shown by later investigations, prevented the action on the liver. In the experiments performed by Rutherford and Vignal, doses that did not purge severely always caused a very decided increase in the bile flow. The composition of the bile did not become changed. They inferred that the augmented flow was due to increased secretion, and not merely to expulsion. Since the influence of bile itself has been carefully investigated on dogs with biliary fistulæ, the decided increase of the bile flow in Rutherford's experiments has been attributed to the bile used as a vehicle for the podophyllin. Rutherford says, in his comment on his ninth experiment, in which he had injected 12.2 c.c. of bile into the dog's duodenum, and about an hour later nine grains of podophyllin suspended in 12 c.c. of bile, that "the increase might possibly have been owing to the injected bile" (*op. cit.*, p. 17).

That podophyllin increases the biliary secretion in consequence of a direct action on the secreting apparatus of the liver is strongly sustained by an extended series of experiments on cats and dogs by Podwyssotzki.[33] He investigated the physiological action of podophyllin, and of podophyllotoxin and picropodophyllin, two active principles he had isolated from podophyllin and from the rhizome of Podophyllum peltatum. Frequently the dejections had a bilious color. In the autopsies he found the liver soft, very dark, and hyperæmic, and the gall bladder much distended.

Neuberger,[34] in experiments in which he investigated the action of crystallized podophyllotoxin, also found the liver hyperæmic and the gall bladder enormously distended with bile. Loewenton,[35] one of Stadelmann's pupils, found in experiments on dogs with permanent biliary fistulæ that small doses of podophyllotoxin promoted the secretion of bile.

Calomel.—This medicine was formerly supposed to be a very powerful cholagogue, because it frequently produces green stools, and was found useful in congestion of the liver. At the present time, however, it is held that, in purgative doses, calomel lessens the secretion of bile.

Numerous experiments to elucidate the influence of calomel on the biliary function have been made, both on human beings and on animals. In all the experiments, when the methods were not faulty, small doses had no effect, and large purgative doses diminished the bile flow. But how explain the green stools and the undoubted benefit resulting from the use of calomel in certain hepatic affections? Do the stools contain large quantities of bile? Of this there can be no doubt, since Michea, Simon, Buchheim, and Radziejewsky found large quantities of bile in calomel stools. Radziejewsky found in calomel stools also notable quantities of the products of pancreatic digestion, peptone, tyrosin, and leucin. The presence of these substances in the dejections has been variously explained. It was supposed that calomel, acting strongly upon the upper part of the small intestine, causes them to be carried forward so rapidly that their absorption is prevented. To the same irritant action on the duodenum was ascribed also the presence of large quantities of bile in the stools, a reflex contraction of the gall bladder and bile ducts resulting which expels the bile previously secreted.

It was surmised by Buchheim[36] that possibly the large quantities of green bile in the evacuations might be owing to arrest of decomposition in the intestines. Wassilieff's[37] researches show that this is probably the correct explanation. Under normal circumstances the bile pigments, bilirubin and biliverdin, are greatly altered by the putrefactive processes taking place in the intestines. Calomel restrains or arrests these decompositions; hence the biliary pigment retains its green color, and, in consequence of the accelerated peristalsis, is discharged before reabsorption can take place.

If it be true that calomel prevents those chemical changes of the bile and of the products of pancreatic digestion that naturally take place in the intestines, and in this way, and in part by accelerating peristalsis, prevents their absorption, it is readily understood why calomel should have been found of special utility in certain hepatic diseases. By diminishing the amount of material absorbed into the portal circulation, it effectually depletes the liver, reduces its functional activity, and lessens the secretion of bile.

In a number of experiments on dogs Rutherford and Dods (*op. cit.*, p. 147) had observed a very decided increase of the bile flow after injecting mercuric chloride into the duodenum. All other observers who have since experimented on dogs or have given this salt of mercury to patients having biliary fistulæ have been unable to verify their observations. It is supposed, therefore, that the increase of bile observed by Rutherford and Dods was caused reflexly by the intense irritation produced by the mercuric chloride in the duodenum of the fasting dogs.

The physiological action of numerous other medicines on the biliary function has been investigated. The following were found, by one or another experimenter, to increase the secretion of bile: aloes, baptisin, colchicum, colocynth, cathartic acid, euonymin, hydrastin, iridin, ipecacuanha, jalap, juglandin, oil of turpentine, potassium chlorate and sulphate, phytolaccin, leptandrin, propylamine, muscarin, salol, rhubarb, and antipyrine.

But with the exception of oil of turpentine, which in combination with ether has been used longer than a century, none is of any practical importance.

Therapeutic Uses of Cholagogues.—Cholagogues are indicated when the secretion of bile is defective, and active hyperæmia, inflammation, and organic diseases of the liver are absent. But there are no certain criteria of this condition. The symptoms pertaining to the alimentary canal, which generally supervene when the flow of bile into the duodenum is impeded or arrested, such as perverted digestion, flatulency, constipation, and impaired absorption of fat, may be caused also by other pathological conditions. If the absorption of fat be found very defective and there be present no evidence of retention of bile, the secretion of bile is probably defective. Cholagogues may then be carefully tried. If the diagnosis be correct, ox gall will doubtless give much relief.

Cholagogues are sometimes useful in the complex disorder known as biliousness, which is characterized by symptoms denoting disturbance of the alimentary canal, liver, and nervous system. The most salient phenomena are a disagreeable or bitter taste, a coated tongue, defective appetite, sometimes nausea and vomiting; a sallow complexion, light-colored stools, and dark or lateritious urine; headache, giddiness, dimness of vision, languor, and mental depression. The primary cause of the disorder is usually a notable derangement of the digestive process, produced by dietetic excesses or the ingestion of indigestible or decomposing substances. In consequence of the perverted digestion, bodies having toxic properties are developed, which, being absorbed into the portal circulation, act deleteriously upon the liver and nervous system.

In the lighter forms of biliousness, which usually last only a few days, cholagogues are not required. Abstention from food and the use of a mild cathartic generally quickly restore the stomach and bowels to a normal state. When the complexion has become sallow, and a deposit occurs in the urine, the treatment that experience has shown to be useful—namely, a purgative dose of calomel or other purgative mercurial, followed by a saline cathartic—is certainly appropriate. If the disorder have existed for some time, alkalies and the cholagogues that produce a free secretion of watery bile, sodium salicylate and benzoate, together with laxative doses of podophyllin, should be resorted to.

Cholagogues are generally used in cholelithiasis. After the severe pain due to the passage and often to the impaction of gall stones in the cystic duct or in the common bile duct has been relieved, sodium salicylate may be given in two or three one-gram doses at intervals of an hour. Each dose should be dissolved in a tumblerful of hot water. Afterward the sodium salicylate may be given in 0.5-gram doses four or five times a day. At the same time it will be useful to move the bowels every morning by means of the artificial Carlsbad salt. The dose of this is generally a heaping teaspoonful, which should be dissolved in about a pint of warm water, one-fourth of which should be taken every quarter of an hour.

If the patient have no icterus, and have repeatedly suffered from attacks of hepatic colic, ox gall will be preferable to other cholagogues. This remedy is more suitable than sodium salicylate and benzoate, because it increases the bile acids as well as the water of the bile, and thus tends to prevent the formation of fresh concretions, and possibly to disintegrate calculi, especially if they consist almost entirely of cholesterin. But to accomplish these purposes its use must be continued for a long time.

If in severe hepatic colic sodium salicylate and Carlsbad salt do not give relief in a reasonable period of time, recourse may be had to olive oil. This should be given in large doses, from six to eight ounces. The following mixture recommended by Rosenberg is less disagreeable to take than the pure oil: oleum olivæ, 200.0; cognac, 20.0; vitell. ovor. ij.; menthol, 0.2–0.5. To be taken in two portions within one hour.

Cholagogues are often used in icterus. When this disease results from thickness and tenacity of the bile, a condition that impedes its free flow through the intrahepatic bile-ducts and causes its absorption by the lymphatics, those cholagogues should be used that increase only the water of the bile, especially sodium salicylate and benzoate.

In catarrhal jaundice not cholagogues, but means to lessen and subdue the catarrh of the duodenum and common bile duct, are of the first importance. Some of the means, however, used to meet this indication do probably increase the secretion of bile; this is true especially of the sodium salts. But whether or not this be the case, sodium phosphate in slightly laxative doses and Carlsbad salt are of undoubted value in catarrhal jaundice. The former may be given in doses of 2 to 6 gm., in much warm water, three times a day. Carlsbad salt is usually given early in the morning on an empty stomach in the dose of one or two teaspoonfuls. This should be dissolved in a pint of water having a temperature of about 100° to 105° F., and drunk in several portions at intervals of ten or fifteen minutes. The patient should defer taking food for one or two hours after the last portion. Often it is found that the symptoms rapidly abate under the influence of sodium salicylate, which may be given to the extent of 3 or 4 gm. daily for some time.

There are cases of catarrhal icterus of great obstinacy, and all the cholagogues mentioned may fail to cause the bile to flow into the intestine. One might then be tempted to use cholagogues that increase the bile *in toto;* but these will probably do no good and may greatly damage the patient.

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CHOLECYSTECTOMY, CHOLECYSTOTOMY. See *Gall Bladder.*

CHOLERA, ASIATIC. See THE APPENDIX.

CHOLERA INFANTUM.—(Synonym: Gastro-Enteritis Choleriformis, Choleraic Diarrhœa, Summer Cholera, Acute Milk Infection.) Cholera infantum is an acute gastro-intestinal catarrh affecting young children, and characterized by large watery stools, profuse vomiting, high temperature, great prostration, and rapid wasting.

It is the most sudden and dangerous form of gastro-intestinal inflammation to which children are liable, and is largely instrumental in causing the excessive infant mortality of the summer months. Cholera infantum is especially a disease of the crowded cities, but is far from uncommon in the sparsely settled country districts.

The custom, so general with physicians everywhere, of grouping all severe infantile diarrhœas under the generic name of cholera infantum, leads to much confusion, and seriously vitiates the deductions drawn from compiled mortuary tables. The term cholera infantum should be strictly reserved for cases of genuine choleriform diarrhœa.

The line of demarcation between cholera infantum and the ordinary summer diarrhœa, entero-colitis, cannot always be sharply drawn. Every epidemic exhibits cases which, beginning with distinct choleraic symptoms, soon subside into more or less protracted intestinal catarrh, and others in which the course of the latter disease is disturbed, perhaps abruptly ended, by an attack of infantile cholera.

But, although this is true, typical cholera infantum contrasts so strongly in symptomatology and fatality with all other forms of summer diarrhœa as to entitle it to a separate chapter and a distinctive name. Little or no difficulty would be experienced if the term were rigidly restricted to the form of gastro-intestinal inflammation outlined in the above definition.

ETIOLOGY.—Cholera infantum finds its analogue in Asiatic cholera. The clinical features of both point unmistakably to a bacterial origin, although no specific organism for the infantile disease has been yet discovered. The evidences of a profound infection are too strong to be ignored.

Infancy, excessive atmospheric heat, improper feeding, bad food, and bad sanitary surroundings are all important factors in the causation. Except in occasional instances they are singly inoperative, but together they develop conditions under which the specific germs or toxins multiply, and exert their deleterious influence on the heart, nerve centres, and intestinal vaso-motor system.

Cholera infantum, as the name implies, is a disease of early childhood, and in the presence of favorable conditions, the liability to its development is in direct proportion to the age of the infant.

It occurs more often during the first six months than at any other period of infancy, and is rarely met with after the completion of the first dentition. There is, however, no ground for the belief that dentition is a factor in the causation, save that the great developmental and functional activity of the intestinal follicles during this period is a powerful predisposing cause to all kinds of intestinal derangement.

Cholera infantum is a disease of the summer months, and attains its greatest prevalence when the thermometer ranges the highest.

In this latitude cases begin to appear in the latter part of May, and occur with varying frequency until October. The disease, however, rarely assumes an epidemic form except in the months of July and August, when it reaches its maximum prevalence and fatality. High atmospheric heat exerts its deleterious influence by enervating the child's physical powers, by impregnating the air with the poisonous exhalations of decaying animal and vegetable matters, and by promoting the growth and distribution of all toxicogenic germs.

Improper food is the cause of multiplied digestive disorders in the infant, but, except in the presence of summer heat, rarely, if ever, lights up a choleraic attack. Its close dependence upon an impure milk supply is well established. A few writers maintain that "the cause is invariably in the food, and the poisons which induce the symptoms are not known to originate in any other food than milk or some milk preparation" (Vaughn). Not infrequently a single improper meal will transform a mild diarrhœa into the graver form of disease, and will sometimes develop an attack when the previous health is undisturbed.

Premature weaning, the use of commercial baby foods, and the American habit of admitting infants to the family table invite the disease. Hand-fed babies, however intelligently cared for, are prone to choleraic seizures, especially when exposed to the anti-hygienic surroundings, personal or domiciliary, of tenement life in the larger cities. For obvious reasons the disease attains its greatest frequency and mortality among the children of the city poor and in foundling hospitals.

Morbid Anatomy.—The pathological lesions vary with the period at which death occurs, and are rarely as pronounced as the alarming character of the symptoms would indicate. In many cases which proceed rapidly to a fatal issue, the post-mortem revelations are negative, or at most only disclose a few patches of arborescent injection scattered over the intestinal mucous membrane. In the more protracted cases, the lesions are better marked, and are very similar to those found in ordinary entero-colitis.

The mucous membrane is reddened, thickened and softened, uniformly or in patches. The intestinal glands exhibit the most constant change. Both the patches of Peyer and the solitary glands are enlarged, and form translucent projections above the surface. Many of these enlarged glands soften, break down, and leave the mucous membrane more or less thickly studded with follicular ulcers. The mesenteric glands are congested. The brain is anæmic and wasted, and serum is freely effused into the ventricles and on its surface. More or less hypostatic congestion of the posterior lobes of the lungs is nearly always observed.

Symptoms.—Cholera infantum usually begins abruptly with violent vomiting and purging, but it may be preceded by a short and ill-defined prodromal stage.

In this latter event, anorexia, fever, fugitive abdominal pains and a few liquid stools precede, for a few hours, or a day or two at most, the peculiar serous evacuations which give character to the attack.

It is a matter of common observation that the disease very frequently occurs in the course of a diarrhœa, more or less protracted, attended with emaciation and associated with intestinal inflammation; but, even in these cases, the distinctive choleraic symptoms almost invariably begin suddenly and are sharply outlined.

The antecedent diarrhœa unquestionably exerts a powerful influence in precipitating the attack, but it is not an essential feature of, nor can it be properly considered a preliminary stage of cholera infantum.

The stools first voided contain the contents of the intestines, milk curds, and particles of undigested food, mingled with intestinal mucus and liquid fæces. As long as fæcal matters are present, the discharges have a peculiarly fetid and penetrating odor, which clings to the clothing and person after repeated washings. These discharges are soon replaced by large odorless stools, devoid of fæcal matter, and so thin as to soak through the diapers like water, leaving only a greenish stain. The number of the stools varies. Ten, twenty or more may be passed in the twenty-four hours; occasionally they recur at long intervals—four or six hours apart—but are so copious as to deluge the clothing and bedding. The discharges are quite irritating, and give rise to an erythema about the anus, which adds greatly to the child's discomfort.

Abdominal pains and tenderness on pressure are usually not marked. Vomiting soon succeeds, or occurs simultaneously with, the intestinal discharges. It may precede them. It is nearly always persistent, and causes the immediate rejection of everything—food or drink—taken into the stomach. The stomach is speedily emptied of its contents, and afterward the ejected matters consist of the food taken, a greater or less quantity of serous fluid, the contents of the duodenum and bile. Even should it subside the taking of drink or food provokes an immediate renewal.

The reaction of the vomited matter is at first acid, but subsequently becomes neutral or alkaline when the intestinal fluids and bile enter largely into its composition. The evacuations, both gastric and intestinal, take place suddenly, with little or no warning, and are ejected with considerable force.

The two symptoms just enumerated—free watery purging and vomiting—recurring again and again, either simultaneously or in close succession, constitute the prominent and distinctive features of cholera infantum.

The quantity of fluid discharged in a few hours through these channels is sometimes enormous. This excessive depletion necessarily causes rapid wasting and speedy exhaustion. Loss of weight takes place more rapidly than in any other disease of childhood. The child soon loses its plumpness, the muscles become soft and flabby, and the skin hangs in folds about the joints. The features become more and more pinched and drawn, and so changed in appearance as to seem unnatural. The child is extremely restless and moans continuously, not so much from pain as from thirst and the general ill-feeling which comes from rapid exhaustion.

Fever is present from the first. The surface may seem to the touch but little warmer or even cooler than natural, but measured by the thermometer in the rectum the temperature, in a case of ordinary severity, will range from 102° to 105° F. "There is no disease of infancy in which the temperature of the blood is higher" (Smith). The mouth soon becomes dry and glazed, and the lips deeply fissured. The tongue is dry and shining or coated with a brown fur. The loss of fluids causes intense thirst, and the little patient eagerly accepts the proffered breast or cup. Water and ice, if allowed, are taken almost incessantly, though rejected by the stomach as soon as they are swallowed.

The secretion of urine is always greatly diminished, and in some of the graver cases totally suppressed.

Cerebral complications develop in a large proportion of the severe cases. These are sometimes due, especially when the urinary secretion is scanty or suppressed, to uræmic poisoning; but are more often attributable to that form of cerebral anæmia which was first described by

Marshall Hall under the name of spurious hydrocephalus. When this condition is imminent, the evacuations suddenly cease or recur at lengthened intervals. The fever disappears and the temperature sometimes drops below normal. The fontanelle, if unclosed, is deeply depressed, and, owing to the wasting of the brain tissue, the bones of the skull frequently overlap and render the surface of the cranium uneven. If the case does badly, the child becomes dull and heavy, the occiput is bored into the pillow, the eyelids remain half-open, the cornea is bleared and the pupils are irresponsive to light. Drowsiness, which has been marked from the first, gradually deepens into fatal coma. Convulsions occur in many of the fatal cases.

The duration of cholera infantum is short. Death may occur in eight or ten hours from the first disturbance of the intestinal canal. The mildest cases rarely last longer than a week, by which time death ensues or convalescence is assured. It must be remembered that an entero-colitis may indefinitely prolong convalescence or even cause a fatal termination long after the disappearance of the choleraic symptoms.

In those cases which pursue a favorable course, the first indication of improvement is the cessation of the vomiting. The child takes food and retains it; next, the diarrhœa becomes less violent, and the fever soon abates. On the other hand, if the profuse flux from the gastro-intestinal tract is not arrested, fatal exhaustion necessarily results. In this event, the face grows more and more haggard and old-looking; the eyes are shrunken, bleared, and surrounded by dark rings; the surface is cold and cyanosed; the respiration sighing, and the pulse uncountable.

Prognosis.—The prognosis is grave. The frequency with which collapse and brain complications arise in cases apparently pursuing a favorable course, always justifies a guarded prognosis. Marked remissions in the symptoms occasionally occur, even in the later stages, and these lead to the building of false hopes by parents and friends. The duration of the disease is largely influenced by the severity of the attack and the vigor of the child. It usually proceeds promptly to death or recovery. A constitution impaired by bad inheritance or previous illness, exposure to unhealthy surroundings, early age, and recent weaning, affect the prognosis unfavorably.

The mortality is greatest in children, under a year old, deprived of the breast.

The choleraic attacks which occur in the course of ordinary summer diarrhœas are less amenable to treatment than those which have developed in rugged health.

The occurrence of collapse, or the hydrencephaloid condition, unless promptly relieved, renders the outlook hopeless.

Death occurs from exhaustion or cerebral effusion. Œdema of the lungs, due to failure of the heart, often hastens the fatal termination.

Diagnosis.—The diagnosis is easily made. In fact, there is no disease, excepting Asiatic cholera, for which it can be mistaken.

The severe serous vomiting and purging, the high fever, the rapid wasting and exhaustion, stamp it with an individuality which almost precludes the possibility of error.

Treatment.—Every case of true cholera infantum should be looked upon by the medical attendant as an emergency case. It is essentially an acute poisoning, in which exhaustion often comes so quickly that intelligent interference is always demanded and demanded promptly.

In the way of prophylaxis the importance of suitable food, good nursing, and proper hygienic surroundings can scarcely be overstated.

During the hot months the most scrupulous cleanliness of person, clothing, nursing bottle, and everything about the infant must be observed.

No case of summer diarrhœa in a hand-fed infant should ever be ignored. Special emphasis should be put upon this axiom, as the writer is thoroughly in accord with Holt that the choleraic symptoms are almost always preceded by some gastro-intestinal derangement.

When the attack develops the coolest and best-ventilated room in the house should be chosen for the patient. It should be darkened and all noises and sources of irritation suppressed.

The first, and an imperative indication, is to assist nature in her efforts to remove the poison from the alimentary tract. There is no time to await the action of the traditional purge, if the stomach did not promptly resent its administration, and emetics are inadmissible. This indication is best fulfilled by lavage of the stomach and enteroclysis. The former rarely fails to lessen or stop the vomiting, and should be employed whenever this symptom is violent and distressing and does not promptly yield to milder means. The stomach should be thoroughly washed with warm, sterilized salt or soda water until the fluid returns clear. Ordinarily a quart will be needed. Oftentimes one thorough cleansing will suffice, but in obstinate cases it may be repeated several times.

The flushing of the stomach should be followed by small doses of calomel (gr. $\frac{1}{10}$) dropped on the tongue every half-hour until from one to two grains are taken.

Thorough irrigation of the colon is of the utmost importance. It should be begun early in the attack and repeated two or more times daily until convalescence is well established.

A flexible tube should be introduced high into the colon and from one to three quarts of water used at a sitting, allowing it to flow in and out freely. The escape of the water may be facilitated by passing a second catheter through the sphincter. To be effective the water must find access to the whole of the large intestine. This douching should be immediately followed, after the method of Professor Cantani, by an equally large quantity of a warm tannin solution (gr. xx. to a pint). "The object of the tannic-acid irrigation is to render inert any soluble poisonous proteids which may remain after the first washing" (Vaughn).

All irrigations should be given slowly, and to prevent undue pressure the water supply should not be raised over two or three feet above the body of the patient.

The child must not be overfed. The intense thirst leads to the eager taking of everything which the mistaken kindness of mother or nurse may proffer. Healthy breast milk should be supplied when practicable. Cow's milk in every form or preparation should be positively prohibited until the brunt of the attack is over. The same may be said of proprietary baby foods. Usually it will be advisable to cut off all foods (not drinks) for the first ten to twenty hours. If this is not deemed judicious, or when feeding is resumed, small quantities of a thin rice or barley water alone, or into which has been strained the white of an egg and seasoned with salt may be given. Later on, animal broths, beef juice, or whey may be added to the dietary, and, still later, peptonized milk and the malted foods.

To relieve the thirst, water may be given freely but in small quantities at a time, or the child may be permitted to suck pieces of ice wrapped in a napkin. A very weak tea, or water acidulated with phosphoric or hydrochloric acid, is both grateful and beneficial. But in severe cases it is not possible to replace the excessive intestinal drain with mouth-given fluids. The indication is, however, fully met with hypodermoclysis.

A saline solution (sodium chloride, gr. xlv. to the pint) warmed (110° F.) and sterilized should be slowly injected into the cellular tissue of the thigh or buttocks. From one to two pints may be given every twenty-four hours.

There is no one remedy in our experience so generally useful as opium, although its use is condemned by excellent practitioners. It should always be given alone: in this way the dose and frequency of administration can be readily changed without interfering with other remedies. It should be, of course, carefully watched and withdrawn at the first appearance of cerebral symptoms.

The hypodermatic injection of morphine (gr. $\frac{1}{100}$) and atropine (gr. $\frac{1}{800}$)* give the best results: other eligible preparations are the deodorized tincture of opium (gtt. i.) and paregoric (gtt. x. to xxx.).

When the violence of the vomiting has abated recourse may be had to the so-called intestinal antiseptics. Sodium salicylate (gr. i.); salol (gr. ss.); creosote (gtt. $\frac{1}{4}$–$\frac{1}{2}$); resorcin (gr. $\frac{1}{2}$), and many other drugs are commended by authors. The writer has been accustomed to rely with the most confidence on the bismuth preparations, of which the subnitrate (gr. x.) and the subgallate (gr. ij.–iij.) are the best.

I have seen good results from the aromatic sulphuric acid (gtt. iij.) given in a teaspoonful of bitter almond water.

French authors speak highly of the nitrate of silver. It may be given by the mouth (gr. $\frac{1}{12}$–$\frac{1}{8}$) or the rectum. When used by rectal injection the anus should be first washed with a solution of common salt, as otherwise even weak solutions may cause severe tenesmus. The hyperpyrexia, which is in itself an element of danger, and the attendant nervous phenomena are best treated by repeated cold sponging or the graduated bath. The use of antipyretic drugs, especially the coal-tar derivatives, cannot be too strongly condemned.

For the bath the child is gently immersed in water at 100° F. when the temperature is gradually reduced by the addition of cold water or ice to 85° F. An ice cap should be worn on the head. The immersion is continued for from ten to twenty minutes and should be repeated whenever the temperature approaches the danger line. It is inadmissable should symptoms of exhaustion or collapse be present.

Stimulants are needed in nearly all cases. It is a common mistake to delay their use too long. If not retained by the stomach they should be given hypodermically and per rectum.

Good old whiskey in gtt. x. to xxx. doses, repeated as required, fulfils every indication. It is surprising how much whiskey can be profitably taken by a child threatened with collapse.

Strychnine nitrate (gr. $\frac{1}{800}$) and atropine sulphate (gr. $\frac{1}{800}$) given hypodermically will often carry a flagging heart over a critical period.

During convalescence the child should be carefully watched, as one attack increases the liability of a recurrence.

W. J. Conklin.

CHOLESTEATOMA is a term applied to a tumor-like mass composed of flat, cornified cells which are usually packed more or less closely together into a spherical, pearl-like, glistening body.

The first to call attention to this tumor was Cruveilhier in 1829; he applied to it the descriptive term *tumeur perlée.* The name cholesteatoma was given it in 1838 by Johannes Müller, who was the first to describe accurately its gross and histological characteristics. Virchow considered the subject very fully in 1855. Recently (1897) it has been reviewed in a masterly way by Bostroem.

Typical cholesteatomata are found chiefly, perhaps exclusively, in connection with the central nervous system and the bones of the skull. Similar pearl-like formations are found in other parts of the body, such as the middle ear, the ovary, and the testicle, but their exact origin has not yet been determined.

In the central nervous system the tumors are found chiefly at the base of the brain, on the posterior surface of the cord, and in the ventricles.

The tumor may form one compact pearl-like body, or consist of one or more pearls and irregular, soft, friable masses. The form is usually round or oval; the surface may be smooth or nodular. The tumor generally occurs singly, but Trachtenberg has reported a case in which multiple tumors were present on the surface of the brain and cord, and in the ventricles.

The size may vary from a pin-head to 5 or 6 cm. in greatest diameter.

The surface of a cholesteatoma usually presents, at least in places, a white, glistening, pearl-like appearance, the pearly lustre being limited to the surface; on section the mass is of a yellowish-white color. The consistence of these growths at the surface is fairly firm, but within it is usually soft and friable.

Microscopically the growth consists of large, flattened, folded, dried up, and cornified cells usually disposed in layers. In at least some of the cells a shrunken nucleus can be demonstrated. Between the lamellæ of cells occur cholesterine crystals to the presence of which the tumor owes its name. In sections the laminæ of cells seen from the side resemble fibrillæ.

The effect of a cholesteatoma on the adjoining brain tissue is purely mechanical. It causes pressure atrophy with increase of the neuroglia tissue.

The origin of these tumors has led to much discussion. Virchow believed that the dried-up cells came from transformed connective-tissue cells. Of late years, however, it generally has been held that the cells are of endothelial or epithelial origin. Bostroem in his monograph comes out very strongly in favor of their epithelial origin, and presents an array of facts which would seem to settle the question for all time.

According to him it is always possible to find at some point in the periphery of the tumor a relatively small, sharply limited area covered with typical epidermis. This represents the growing part of the tumor mass; the rest of it is made up almost entirely of dead, desquamated cells. The growing cells undergo cornification and in a certain layer, as in the skin, produce granules of keratohyalin. They also give rise to drops of eleidin and crystals of cholesterine.

The epidermis with an underlying connective-tissue layer derived from the pia or a choroid plexus forms a membrane which may cover a varying proportion of the cholesteatoma, but never the whole of it. The rest of the tumor is uncovered or adjoins brain tissue or pia.

Bostroem believes that these tumors arise from aberrant epidermic cells which become included in the central nervous system at the time of its formation. The aberrant cells develop in case they find proper conditions for nourishment; this happens only when they come in contact with the vascular pia or a choroid plexus. The growing part of the tumor, therefore, is always attached to one or the other.

The epidermic origin of these cells is based on their arrangement in the form of a pavement epithelium, on their producing keratohyalin and undergoing cornification, and on the formation of eleidin and of cholesterine crystals. Bostroem proposes that these tumors, in view of their origin, shall be called epidermoids.

Another point in favor of the epidermic origin of the cholesteatomata is the fact that a few of them are found containing hair. This is to be explained on the supposition that the aberrant cells in these cases consisted of cells not only from the epidermis but also from the cutis. The growing surface in these cases contains hair follicles and sebaceous glands. This class of cholesteatomata should be classed with the dermoids.

The cholesteatomata which occur in certain bones of the skull probably owe their origin also to aberrant epidermic cells which grow in the vascular marrow and derive their nourishment therefrom.

We have had at the Boston City Hospital, during the past two years, three cases of cholesteatoma of the brain.

The first consisted of a pearl the size of a pea and of several small, irregular, white, friable masses more or less embedded in the cerebellar tissue on the left side just where it joins the pons.

The second tumor was larger, measuring 3.5 cm. in diameter and 2 cm. in thickness, and was attached to the velum interpositum at the posterior end of the third ventricle.

The third tumor was still larger. It lay at the base of the brain on the right side and extended from the optic commissure out beneath the right frontal lobe. It was irregularly oval in shape, measuring 7 cm. in length and 3.5 cm. in diameter. It lay beneath the pia and had so shoved itself into, displaced, and compressed the adjoining brain tissue that it might almost have been thought to have originated within it (Fig. 1290).

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* The doses given in this article are for a child one year old.

The histological appearances of these three tumors agree in all respects with the description given above.

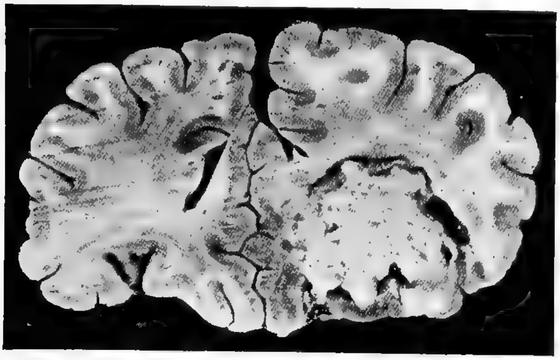

FIG. 1290.—Section of the Brain in the Third Case Mentioned Above, showing how the cholesteatoma in its anterior portion has pressed into the substance of the brain. (Original.)

For a complete bibliography up to time of publication see Bostroem; *Centralblatt für Pathologie*, 1897, viii., 1. For multiple cholesteatomata see Trachtenberg, Virchow's *Archiv*, 1898, cliv., 274. *F. B. Mallory.*

CHOLESTERIN ($C_{26}H_{44}O$).—As its name indicates this substance was first recognized as a constituent of the bile and was regarded as a bile fat (cholestearin); but its proper designation is cholesterin (bile solid). When pure it crystallizes in white mother-of-pearl leaflets which have a fatty feel but possess no taste or odor. It has a neutral reaction, melts at 145° C., and sublimes without change in a vacuum at 360° C. According to its reactions it is probably a monovalent alcohol.

Cholesterin is insoluble in water, dilute acids, dilute and concentrated caustic alkalies, and in cold alcohol. It is soluble in hot alcohol, ether, chloroform, benzole, and in the volatile fatty oils; but dissolves with difficulty in solutions of the bile-acid salts, and is only slightly soluble in water solutions of soaps. The solution in ether is neutral, and turns the polarized ray of light to the left.

From ether solutions cholesterin crystallizes on evaporation in large, thin, transparent, rhombic plates, ($C_{26}H_{44}O + H_2O$), whose edges and corners are frequently irregularly notched, so that the plates as they lie heaped up have the appearance of being cut out in step-like forms. The formation of the plates is frequently preceded by a stage of fine needles which gradually change into blunt cones and then pass into the plate form. Cholesterin is unchanged by the action of boiling caustic alkalies. With concentrated nitric acid it yields cholesteric acid ($C_{12}H_{16}O_7$) in addition to acetic and butyric acids. Concentrated sulphuric acid gives cholesterin a red color, and breaks it up into a variety of isomeric hydrocarbons (cholesterilin). When heated with organic acids for long periods of time at 200° C. cholesterin passes into ether combinations: as for example with acetic acid it forms acetic-acid-cholesterin-ether, ($C_{26}H_{43}$-C_2H_3O,O).

When treated with a mixture of five parts concentrated sulphuric acid and one part water, cholesterin crystals take on a deep carmine red which gradually passes into violet. A weaker solution causes a violet coloration of the edges of the crystals which on the addition of water becomes lilac. Sulphuric acid containing a trace of iodine colors the crystals violet, blue, green, and red.

If cholesterin is dissolved in chloroform in a dry test tube, and acetic acid anhydride added, the addition of concentrated sulphuric acid, drop by drop, produces a rose color which quickly becomes blue and after a few minutes changes to vivid green. When only very small amounts of cholesterin are present the green color alone appears. This is one of the most reliable tests for this substance, and the presence of .05 mgm. can be shown by it. When substances containing a small amount of cholesterin are evaporated with a drop of concentrated nitric acid upon the water bath, a yellow coating is left which on the addition of ammonia becomes bright red.

Cholesterin is a constant constituent of the bile of all animals, in which it is held in solution by the bile-acid salts and the soaps. The proportion in normal human bile has not yet been ascertained. It is also found in the intestinal contents as a result of the presence of the bile. In the blood it occurs only in a very small amount, which is held in solution by the fats and soaps of the blood. The various nerve structures contain it in large proportion; more than half of the dry substance of nerve fibres consists of fat and cholesterin; the gray matter of the brain contains about one-fifth. Burchard has found traces of cholesterin in every organ and tissue of the body. It is found also in roots and seeds, especially in peas, beans, and the cereals. From its wide distribution cholesterin may be said to be a constant and essential constituent of both animal and vegetable protoplasm.

Under certain pathological conditions the cholesterin of the bile may be separated, giving rise to the formation of calculi, which consist largely or entirely of cholesterin or of cholesterin in connection with bile pigment, phosphates, carbonates, etc. An ethereal extract of the crushed calculi will yield cholesterin crystals on evaporation. The tests mentioned above may be applied to the extract.

Cholesterin is also found in old exudates and in the contents of cysts, especially in ovarian and hydrocele fluids. In these it may occur in so great an amount that the crystals may be seen with the naked eye as small shining particles. It may be found also in the fatty changes occurring in atheromatous conditions of the blood-vessels, wens, cholesteatomata, caseating tubercles, and degenerating tumors. It is a constant constituent of pus, probably arising from the fatty degeneration of the leucocytes. Cholesterin crystals are also found in echinococcus cysts, and rarely in cataractous lenses.

The origin and fate of cholesterin in both the plant and the animal organisms are unknown. It is most probably an intermediate product in the metabolism of proteids, but the physiological significance of this substance remains to be discovered. It is not excreted in normal urine. Its pathological significance is likewise obscure. Austin Flint's view that the severe nervous symptoms in icterus gravis are due to the retention of cholesterin is not supported by animal experiments. Injections of cholesterin into the blood stream of dogs produce no pathological effects. It is more probable that these symptoms are due not to cholesteræmia but to the presence of some poison not yet discovered. *Aldred Scott Warthin.*

CHOLINE.—Choline is a basic body derived from ammonium hydroxide; it is, in fact, trimethyl-oxyethel-ammonium hydroxide, and is represented by the following formula:

$$N\left\{\begin{array}{l}(CH_3)_3\\ C_2H_4OH\\ OH\end{array}\right.$$

It was discovered by von Babo and Hirschbrunn in the seeds of white mustard and named by them sinkaline.

The same body was isolated from the animal body in 1862 by Strecker[1] and named by him choline, since he obtained it from bile. The closely related but far more poisonous base, neurine (trimethyl-vinyl-ammonium hydroxide), was discovered about the same time; the name neurine has been frequently applied to choline, and much confusion has thus arisen. Choline may be made synthetically by the union of ethylene chlorhydrin and trimethylamine; it can also be obtained from a large number of animal and vegetable tissues. It is obtained with the greatest ease from the yolk of eggs and from brain by boiling these with barium hydroxide. Free choline forms a strongly alkaline syrup which dissolves fibrin; it was at one time used to dissolve the false membrane in diphtheria. With acids it forms salts which are easily soluble in water. It is easily decomposed by heat into trimethylamine and glycol.

Choline occurs in the animal body chiefly, if not exclusively, in lecithin and its compounds or as one of the decomposition products of this substance. As lecithin is found, so far as is known, in every animal and plant cell, it is evident that choline is very widely distributed; it probably plays a more important rôle in life processes than is generally recognized. The ease with which lecithin is decomposed by the simplest chemical processes makes it difficult to determine whether the choline obtained from a given organ was present as such or was split off from the lecithin during the chemical manipulations. So far it has been found with certainty in but few organs and fluids—in the brain by Gulewitsch,[2] in the semen by Gumprecht[3] and others, in the cerebro-spinal fluid and blood of cases of general paralysis of the insane by Mott and Halliburton,[4] and probably in the suprarenal gland. Nesbitt[5] has found it in the intestine of the dog after a meal rich in lecithin (eggs); Marino-Zucco and Dutto claim to have found it in the urine in cases of Addison's disease: it has been found in cultures of the comma bacillus and other micro-organisms. It can be obtained from most organs of the body after decomposition has set in.

Choline was for some time regarded as inert physiologically; more recently it has been shown to be a poison of considerable power. Thus Brieger[6] found that 0.5 gm. per kilogram is fatal to rabbits. Many of the statements concerning the physiological action of choline are to be received with great caution, for most of the older and some of the more recent experiments were evidently made with preparations mixed with the very poisonous base neurine. In frogs choline is said to produce general paralysis from a curare-like action upon the terminations of the motor nerves. Injected into mammals choline causes salivation, diarrhœa, and very characteristic changes in the circulation; the latter have been studied with especial care by Mott and Halliburton. The heart is slowed from a stimulation of the endings of the cardio-inhibitory nerves; the blood pressure falls greatly. Mott and Halliburton have shown that the fall of blood pressure is due largely to a dilatation of the peripheral vessels, especially those of the intestinal area; the slowing of the heart may account in part for the fall of blood pressure. These changes in the circulation are very transient. Atropine is an effective antidote to choline.

Choline has attracted most attention from the toxicological standpoint on account of its close chemical connection with the highly poisonous substances neurine and muscarine. By the loss of one molecule of water it is converted into neurine, while on oxidation it yields a very poisonous compound isomeric with muscarine, the poisonous principle of many mushrooms. Neurine, which is found in decomposing meat, brains, mushrooms, etc., is always accompanied by choline, and it is very probable that the former is derived from the latter. The transformation of choline into neurine can be easily accomplished by chemical processes, but the conditions under which this change takes place in the animal body are obscure. Micro-organisms, however, seem to bring about this conversion: thus Schmidt[7] found that when choline was mixed with hay infusion or decomposing blood and allowed to stand a few days a substance having the chemical and physiological properties of neurine, and probably identical with it, was formed. Nesbitt has obtained a substance which he considers to be neurine from the intestine of a dog after feeding the yolk of eggs; he thinks this body is derived from the choline formed by the decomposition of the lecithin. The conversion of choline into neurine by putrefaction may explain the production of poisons in foods; perhaps the choline itself, which has an action similar to but less powerful than neurine and muscarine, may be partly responsible for some of the symptoms observed in cases of poisoning with decomposing meat or mushrooms.

Attention was called above to the fact that Mott and Halliburton have found choline in the cerebro-spinal fluid and blood in cases of general paralysis of the insane. They are inclined to think it possible that this substance is responsible for the low blood pressure which is found in the later stages of this disease. I have been led to believe from investigations of my own that there are substances in the brain, and also in the suprarenals, which yield choline on decomposition and which have a more marked toxic action than choline. I have not been able to determine the exact nature of these substances, but it seems possible that some of the effects ascribed by Mott and Halliburton to choline may be due to such antecedent substances. *Reid Hunt.*

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CHONDROMA.—(*χόνδρος*, cartilage.) DEFINITION.—A chondroma is a histoid or connective-tissue tumor of which the essential constituent parts correspond to some one or more of the several varieties of cartilage, these cartilaginous elements differing to a greater or a less degree from the normal, and having associated with them other sorts of tissues. The term now includes those cartilaginous new growths which arise from structures containing cartilage normally, formerly called "ecchondroses"; as well as those which develop in regions where normally no cartilage is present, formerly known as "enchondromata." This form of tumor occurs ordinarily in the shape of sharply circumscribed, rounded, or knobbed growths, sometimes multiple, which may reach a very considerable size, and may develop in almost any part of the body, more commonly about the bones, and in certain glands.

VARIETIES.—Several varieties of chondroma may be recognized, the distinction between them being based upon the character of the cartilage present, and also upon the nature of the tissue or tissues associated with the cartilage in the tumor. Every sort of cartilage present in the body is represented in chondromata, and other forms may occur for which no analogue exists in normal structures. Thus, a chondroma may be found to consist of hyaline, fibro-, or elastic cartilage, or to contain cells distinctly cartilaginous in appearance and embedded in a soft, semi-gelatinous, mucoid substance. The complex forms of chondroma produced by the association of cartilage with other varieties of new growth include: chondro-lipoma, chondro-myxoma, chondro-fibroma, chondro-angioma, chondro-endothelioma, chondro-myxosarcoma, and osteo-chondroma.

STRUCTURE.—A simple chondroma is composed of small masses of cartilage embedded in a fibrous connective-tissue stroma. The consistence of the tumor and the appearance of the surface of section are determined by the character of the cartilage and by the nature and the degree of development of the stroma. Chondromata made up of hyaline, fibrous, or elastic cartilage usually have a firm consistence, while those in which the cartilaginous elements present a mucoid intercellular substance are soft and resemble myxomata. A chondroma in which the fibrous connective-tissue stroma is very abundant may present the macroscopic characteristics of a fibroma; such a chondroma best illustrates the tendency which this kind of tumor possesses toward an alveolar type of structure, the appearance of the cut surface suggesting that the growth is composed of a great number of small tumors separated from one another by septa of connective tissue. In some instances large masses of cartilage are found detached from the main body of the tumor;

these give to the tumor its rough, knobby feel. It is probable that these separated masses have assumed their position as the result of the development of the stroma, and that they are not the product of several centres of growth. The cartilage cells of the chondroma may resemble normal cartilage cells, consisting of cell, nucleus, and capsule; not infrequently, however, they are without a capsule, and differ from the normal in number and in size. At times, along with cartilage cells of the ordinary form there are stellate cells, and elements which correspond to the round and the spindle-shaped cells of connective tissue. The cells vary much in shape and in size; in the hyaline chondromata they usually are round and large; in the fibrous form they are often small and irregularly shaped. When the intercellular substance is soft and similar to mucus, the cells are frequently spindle-shaped, with long anastomosing processes. Virchow has observed amœboid movements in such cartilage cells, and is disposed to regard them as a cause of malignity. Most chondromata upon boiling yield chondrin; this is not true of those which have a soft intercellular substance, such forms yielding an albuminous or a mucin-containing material. In some instances, the stroma of the tumor is composed of embryonic connective-tissue cells, and the cartilaginous elements consist of small scattered groups of cells; such tumors often occur in the testicle, and are termed chondro-sarcomata.

The blood-vessels of the chondroma, which lie in the stroma, may be very abundant, especially in rapidly growing tumors, and not infrequently are embryonic in character. Neither lymph vessels nor nerves have been demonstrated in this form of tumor.

Chondromata are often separated from adjoining structures by a connective-tissue capsule. In chondromata which develop in the centre of bones such an enclosing capsule is composed of bone, formed probably from the enveloping periosteum; this capsule is complete usually in the early stages of the growth only, subsequent development causing it to be broken through.

Certain structural properties of the chondroma are characteristic of its place of origin. The chondroma arising from bone usually contains hyaline cartilage, more rarely fibrous, and sometimes mucous, the malignant chondromata of bone ordinarily being of the latter sort. The chondromata of the soft parts usually present fibrocartilage, more rarely hyaline; they seldom are simple, being commonly associated with either myxoma or sarcoma. Chondromata arising in these parts have also a tendency to ossification and to calcification. In a chondro-endothelioma of the ear, von Dembowski found the cartilaginous elements of the tumor to arise by metaplasia from the hyperplastic endothelium of the widely dilated and cavernous blood-vessels of the growth; the endothelial cells became separated into clumps by a hyaline intercellular substance, subsequently underwent further isolation, and finally passed from a polygonal to a round form, and developed capsules.

Locus; Mode of Growth.—Chondromata may develop from any one of the connective tissues. The most common seat of origin is bone. Here the chondroma may consist of a circumscribed hyperplasia of cartilage, or occur as a new growth of the medullary canal of the long bones. In the former instance the tumor has but little tendency to growth, and is, except from its possible position, benign; it may become pedunculated, or even break off and thus form one of the foreign bodies found in joints. The tumor may also arise from the fibrous connective tissue of the periosteum; the capacity of the latter structure to form cartilage is shown by the production of it after fracture. Lücke has found that the development of cartilage from connective tissue takes place through the agency of groups of indifferent cells in the tissue, which secrete an intercellular substance. Virchow describes a more direct transition; he assumes that the fibrous tissue becomes more dense and undergoes a form of sclerosis, that the cells increase in size, and that in this way takes place a direct transformation into hyaline cartilage. The other forms of chondromata of bone are either peripheral or central in their position. The peripheral forms constitute large, rough, knobby tumors, which may surround the bone, and from pressure cause it to atrophy, the soft parts being pushed to one side; they usually possess a bony capsule. Such chondromata are most commonly found upon the pelvis near the symphysis, upon the scapula, and upon the upper jaw; they occur in the later years of life. The chondromata which develop in the medullary portion of bone, known as central chondromata, occur most commonly in the phalanges of the fingers and the toes; they are often multiple, especially in children, and give rise to protuberances known to the older writers under the name of spina ventosa. These tumors have a partial or a complete bony capsule, although this is sometimes absent, or is represented merely by fragments of a thin osseous plate. They appear during the period of life in which the skeleton is growing most actively. The long bones of the upper extremity are also often the seat of these tumors.

Of the soft parts, certain glands are the most frequent locus of primary chondromata. This form of tumor is found in the parotid gland, in the testicle, more rarely in the submaxillary gland, in the breast, and in the ovary. It sometimes occurs in the lachrymal gland and in the kidney; the chondromata of the kidney are possibly analogous to those tumors of this organ which contain striated muscle fibres, and are of embryonic origin. Primary cartilaginous tumors have also been observed in the thyroid gland, in the skin, and in the lungs. Birch-Hirschfeld has observed a large chondroma originating from the cartilage of the trachea of an old man, which produced a fatal stenosis of the trachea.

The chondroma has a marked tendency to occur as a multiple tumor; cases have existed in which all of the fingers of an individual were at the same time the seat of this form of new growth. In general, however, the tumors are limited to that portion of the body in which they originate; they do not tend to produce metastases. When metastasis does take place, it is usually when the chondroma is complex, and has associated with it osteoma or sarcoma. When metastasis of simple chondroma occurs, it is usually in consequence of the breaking through of the tumor into a vein, by means of which tumor elements capable of development are carried as emboli to more or less remote parts of the body. The most frequent locus of secondary chondroma is the lung; Birch-Hirschfeld has observed a secondary nodule upon the endocardium of the right ventricle of the heart. In Weber's classical case, a man of twenty-five years died with chondromata scattered over his entire body; the largest of these was seated upon the ilium; others were upon the scapula, upon the clavicle, and upon the ribs. At the autopsy, numerous emboli were found in the branches of the pulmonary artery, some of which were of recent origin, while others presented a distinct growth of the embolus into and around the vessel. Upon examination, the emboli were all found to be of the same nature as the tumors upon the skeleton. The source of the emboli was a large tumor growing into the left iliac vein. Paget has reported a case very similar to this. The lymph nodes are seldom involved. In one case a metastatic nodule has been observed in the spleen. Metastases in the liver are also very rare. The exemption of the lymphatic system is probably due to the compactness of the chondroma, and the large size of its cells, together with the fact that the tumor does not stand in very close relation with the lymph spaces. The chondromata which arise from normal cartilage, in so far as the production of metastases is concerned, seem to be wholly benign, and the differentiation of these from other chondromata under the name of "ecchondroses," as was done by Virchow, is of some clinical significance.

The rate of growth of chondromata is in general slow, but steadily progressive; in some instances periods of rapid growth alternate with intervals of repose. The complex forms, especially the osteo-chondromata, tend to grow more rapidly than do the simple forms. Notwithstanding its slow rate of growth, the chondroma may attain a very large size, even that of a man's head.

In the course of development of a chondroma, the soft parts are crowded aside; tendons may make deep indentations in the tumor, and even run through it in canals made by the bridging over of such indentations. In the chondromata of the ends of the bones the articular cartilages play no part in the development of the tumor, but are overgrown and covered by the new growth.

Retrograde metamorphoses are especially characteristic of the growth and the development of the chondroma; the comparatively small blood supply of the tumor and the difficulty of nourishing the circumscribed masses of newly formed cartilage adequately explain this. Calcification is frequent; it may occur in the form of scattered islets of calcareous material, or of hard lamellæ, the latter being easily mistaken for bone. In the process of calcification, calcareous material is deposited first in the cell capsule, then in the cells, and finally in the intercellular substance. Ossification takes place about as frequently as calcification, and occurs not only in chondromata of bones, but also in those of the soft parts. The process is characterized by the formation of spicules and septa of bone which intervene between groups of cartilage cells. Very often there takes place the formation of isolated osseous plates, or of a spongy bone with well-marked Haversian canals. In chondromata which develop from bone, the new growth may contain remains of the old bone enclosed in the newly formed cartilaginous tissue.

Myxomatous softening, with associated cyst formation, is frequent in chondromata. If this metamorphosis takes place throughout the whole extent of the tumor, there are formed, between the trabeculæ of the stroma, cysts of varying size, with yellow or gray contents. The process is characterized by a fatty degeneration of the cartilage cells, which thereby become filled with fat drops and are changed into granular corpuscles. The intercellular substance undergoes softening, with the formation of a mucoid substance, and from the blood-vessels take place hemorrhages which give to the softened mass a dark-brown color. In some rare cases, the skin over a chondroma becomes ulcerated, and a fistulous opening develops into one of these cysts of softening.

The teratomata, or mixed tumors, especially those of the sacrum, frequently contain cartilage in association with other tissues; these tumors constitute a distinct group.

The osteo-chondroma, described by Virchow, is a form of complex chondroma in which ossification takes place chiefly by the deposition of lime salts in the intercellular substance. The cartilage cells of this tumor are similar to those which occur in the course of the ossification of the long bones; the cells generally possess no capsule, and are distinguished from connective-tissue cells by their shape. This form of chondroma is most often found upon the long bones, where it produces very large masses. The growth is usually surrounded by a bony capsule formed from the periosteum. Softening in this variety is not common.

As to recurrence of chondromata after removal, it may be said of this class of tumors in general that they do not tend to return. This is true especially of chondromata of the soft parts, and of those of the phalanges; it is not the case with chondromata of certain other regions, notably the bones of the pelvis. Virchow reports one instance in which the tumor was removed seven times at intervals of from six months to two years.

Etiology.—The beginning of the growth of a chondroma is often traceable to a very early period of life; in some instances, especially those in which the growth arises from bone, the tumor is congenital. Chondromata of the soft parts usually develop later in life.

Trauma is often alleged to be a cause for the occurrence of a chondroma either in the soft parts or in bone. The form of injury most frequently regarded as standing in a causal relation to the development of chondromata is fracture of a long bone; tumor formation in such a case may be looked upon as due to some irregularity in the reparative process which follows the injury.

For the occurrence of chondromata of the bones, irregularity of development is the probably correct explanation. In favor of this point of view may be considered the fact of the multiple character of these tumors, and their appearance in that period of life in which the skeleton is growing most actively. Cohnheim's theory of the formation of tumors, which asserts that new growths arise from vestigial embryonic tissue, seems to find confirmation in the case of the chondroma. Virchow found that remains of embryonic cartilaginous tissue are often enclosed in the medulla of the long bones, and it is probable that such remains are the immediate antecedents of many chondromata of the bones. The cause of the persistence of this embryonic tissue may be a disturbance of blood supply, or an excessive growth of the primary cartilage. A form of chondroma which arises in the spheno-occipital synchondrosis is by some authorities believed to develop from surviving embryonic cells of the chorda dorsalis. Irregularity in the post-fœtal development of bones, as in rachitis, is also held to stand in relation to the occurrence of chondromata; under these circumstances, islands of cartilage remain in the bone, from which tumor formation may proceed in childhood or later life.

For the occurrence of chondromata of the soft parts, misplaced embryonic cartilaginous elements are probably responsible. Thus, primary chondroma of the lungs may proceed from detached portions of the primary cartilage of the respiratory tract, and chondroma of the breast from that of the ribs. The chondromata of the thyroid gland and of the parotid gland may arise from the cartilage of the branchial clefts. The same is probably true of certain cartilaginous tumors of the skin. The simple chondromata of the testicle and of the ovary may arise from islands of cartilage detached from the primary cartilage of the notochord. The occurrence of the cartilage-containing mixed tumors in the various organs may rightly be referred either to a detaching of parts of an adjacent cartilaginous Anlage, or to a heteroplastic development of mesenchymal cells.

Diagnosis.—A firm, hard tumor seated upon cartilage or upon bone should always suggest chondroma. In some instances, the early stages in the development of a chondroma may resemble an osteitis, or a periosteitis. Chondroma is differentiated from fibroma by its hardness except when the latter is calcified, and from other tumors, including osteoma, by its rough, uneven surface. The central chondromata of bones may often be recognized by the parchment-like feel of their bony capsules. The chondromata of the soft parts are usually easily to be diagnosed from their firm consistence, uneven surface, and slow growth.

George Burgess Magrath.

CHONDRO-SARCOMA. See *Sarcoma.*

CHORDEE (Chorda venerea) manifests itself in more or less persistent erections, during which the penis is curved like a bow or bent at an angle. Near the centre of the concave side of the bow and at the interior of the angle, palpation reveals hardening of the tissues. This hardening may be circumscribed or diffuse. The patients compare their sensations during chordee to the feeling of a tense string or a red-hot wire drawn through the penis or urethra.

Chordee is due to cavernitis, either of the penis or of the urethra, or of both, in hyperacute gonorrhœa; it may also be produced by the use of excessively strong injections, by an injury to the urethral mucosa, by the use of a sharp-pointed syringe, or by the unskilful introduction of instruments, during the acute stage of urethritis. It may, futhermore, be due to infarction of urethral crypts and glands, with or without consequent peri-urethral or cavernous abscess. In some cases induration continues without either of these terminations for years, and may then become an impediment to copulation on account of deflection of the penis during erection.

In chordee the penis is bent in the direction of the infiltration that causes it, because the infiltrated part does not take part in the general turgescence of erection. The intense pain produced by such erections may drive the patient to desperate measures, such as placing the organ upon a hard surface and striking it a violent blow "to break the cord." Some patients have sought relief by coitus. The results of such violence may be urethral rupture, fatal hemorrhage, urinary extravasation, and consequent death from urinary infection, laceration of the corpora cavernosa, and gangrene of the penis. Even in those cases in which neither a stricture nor any one of the results just enumerated occurs, the part of the penis in front of the injury may thenceforward be cut off from sufficient blood supply to enable it to participate in erection.

Treatment.—In the acute stage, rest in bed under light covering, a low diet, purgatives, camphor or its monobromate, with or without opium, may be prescribed with advantage; locally, hot sitz-baths, hot or cold compresses—whichever the patient finds most soothing—and leeches to the perineum, are indicated. In hyperacute cases, the infiltrated tissues may be punctured with fine needles, as a last resort, if the other treatment does not suffice. If an abscess forms it must be opened early to prevent its breaking through into the urethra. In chronic cases, where the infiltration has become solid and gives but little or no pain during the deflected erection, galvanism may be used to stimulate absorption of the infiltrated material. If it is employed the negative pole should be applied to the infiltrated tissues and the positive to the opposite side of the penis. At first a low amperage should be used for several minutes, but afterward the séances should gradually be lengthened until they reach a term of from twenty to twenty-five minutes each.

Ferd. C. Valentine.

CHORDOMA.—The term used by Ribbert to designate a small tumor found occasionally in the median line of the clivus, near the union of the sphenoid and occipital bones; a tumor to which Virchow had previously given the name of *ecchondrosis physalifera spheno-occipitalis.* The growth, to the naked eye, has a colloid or gelatinous appearance, and is usually about the size of a small cherry. It arises out of the spheno-occipital synchondrosis, and either occupies the space between the bone and the dura mater which may not be perceptibly elevated, or it may break through the dura into the arachnoid and pia. In longitudinal sections of the clivus the tumor is found to lie in a small cavity which involves only the superficial portion of the bone or it may extend into the medullary portion. In young individuals whose synchondrosial cartilages are still present earlier stages of the tumor may be found. In these cases there is present beneath the dura, which is usually not elevated, a small round or flattened mass of tumor tissue lying in the cartilage from which it is sharply though irregularly outlined. No evidence of transition between the tissue of the new growth and that of the neighboring structures is ever observed.

The tissue of the tumor when examined in the fresh state is found to consist of large bladder-like cells resembling plant cells. These are easily isolated by teasing in normal salt solution. They contain numerous vacuoles of varying size which may so fill up the body of the cell that the protoplasm appears to be pushed in a narrow ring to the cell periphery. Few of the cells are free from vacuoles. The protoplasm is clear and contains fine shining granules. The small round nuclei appear bright and clear. The gelatinous portions of the growth break up in water. In hardened preparations the vacuoles appear still more prominent, but are oval or flattened rather than round. The protoplasm appears in less amount, but the small round nuclei are brought out very distinctly. These lie either at the edge of the vacuoles, or when the cells are seen from above they appear to be in the centre of the vacuole. Between the cells lies a homogeneous hyaline intercellular substance varying in amount in different portions of the growth. No blood-vessels have been found.

Virchow regarded the growth as a chondroma developing from the remains of the spheno-occipital cartilage, the cells of the cartilage having undergone a peculiar bladder-like degeneration. But the character of the tissue as well as the relations of the tumor makes it very probable that it represents remains of the tissue of the chorda which have taken on proliferative activity.

Aldred Scott Warthin.

CHOREA.—(Synonyms: Sydenham's Disease; St. Vitus' Dance; Danse de St. Guy, de St. With; Myotyrbie [Dartigues]; periodical jactitation [R. Watt]; Chorée, Veitstanz, Veitsdands, Vit-Táncz; Plasawicy scelotirbe; Corea; Folie musculaire [Bouillaud].)

The literature of chorea is extremely voluminous, and its history dates back to the middle ages, when it existed chiefly in its epidemic form. Hecker[1] and others detail the incidents of the various religious pilgrimages to the shrines of St. John and St. Vitus, and the imitative features of the outbreak of psychical excitement with convulsions and jactitations are of the greatest interest. In many respects this form of trouble, apart from its general character, differs but little from that in which attacks of hysterical chorea major are witnessed to-day.[2] Puccinatti and other writers have undertaken to fix the identity of sporadic and endemic chorea, and to some extent they have succeeded; but when we consider the probable pathology of the disease from the standpoint of modern investigation, it must be admitted that the psychical element is by no means an important one. During the last twenty-five or thirty years, thanks to Kirke, Ogle, Dickinson, Dowse, Jackson, Eisenlohr, and Elischer, the relations of the disease to affections of the heart, to embolism, and to rheumatism have been made very clear, and within a comparatively short space of time the organic variety known as post-hemiplegic chorea, or hemichorea, has been fully described by Mitchell, Charcot, Hoffman, Jackson, and others.

Chorea is a disease which manifests itself in an exceedingly irregular manner as to the parts affected, and the degree of violence of expression, and as to its association with or dependence upon other things. The affection is characterized by a peculiar disorderly and nearly constant recurrence of muscular contractions of an involuntary character, which are not (except in hysterical cases) at all rhythmical. It has been divided into *general chorea*, or *chorea major*, and *partial chorea*, or *chorea minor*, and the manner in which it is associated with other pathological conditions still further demands a series of qualifying terms, such as *hysterical, saturnine, procursive, habit, senile, rheumatismal, dental, enteric, hereditary*, or *Huntington's electric* (of Dubini or Bergeron), the *chorea of insanity*, the *chorea of pregnancy*.

Symptoms.—Chorea may follow some other affection—one of the ordinary diseases of childhood, for instance—or it may be the sequel of an attack of acute rheumatism; or again, it may have no basis except a general reduction of vital power with anæmia and its belongings. In such cases the development of the malady is slow and insidious, and the child for a long time presents simply those evidences of neural malnutrition which are so common. It is peevish and capricious, and restless in the extreme. Its petty exhibitions of temper render it a nuisance, and it receives its full allowance of punishment. The same caprice of disposition is found in eating—it prefers improper food, and at best eats but little. It is listless and dull at school, sleep is disturbed, and frightful dreams produce night terrors and nocturnal incontinence. Its pale face makes more conspicuous the dark spots under the eyes, and its foul breath and dry teeth betoken a derangement of digestion. After a while it begins to shrug one shoulder or the other, and twitches its hands, or fumbles the seam of the trousers, or opens its mouth with a sort of gasping movement, or twitches its lips, or corrugates its brow, or spasmodically closes its eyes; or does something else that may be regarded as a trick or bad habit. Scolding or whipping does not effect a change of behavior—in fact, it rather aggravates the trouble. In a week or two the movements are more pronounced or general, the arm is swayed hither and thither by the action of the pectoral muscles, or the hand is supinated or pronated, the fingers restlessly cramp, the lips are pursed, and any attempt at speech is attended by hesitation and embarrassment, and oftentimes by great indistinctness. The patient breathes in a catchy, quick way, and if the body be stripped it will be found that the action of the intercostals is uneven. There is rotary swaying of the body, constant shrugging of the shoulders. The leg of one side—usually the right—is affected, and after a while there is greater or less loss of power, so that there is a well-marked dragging of the limb, which is usually more noticeable toward the latter part of the day. All the voluntary muscles are more or less affected, and as a rule those are most involved which are used to the greatest extent in acts which become automatic. In the form known as laryngeal chorea the thyro-hyoid muscles are affected, and phonation becomes seriously embarrassed. The tongue, when protruded, is found to be the seat of jerking spasms, and when the patient talks he makes a peculiar sucking motion of the lips.

Symptoms of spinal sensory irritation mark the prodromal period, and we are furnished with a history of pains and sensitiveness of the vertebral spines.

Pressure on the cervical region sometimes causes great distress, and especially is this the case when even light pressure is made upon the *vertebra prominens*. The patient complains of pains in the wrists and ankles, which suggest rheumatism, and the bellies of the affected muscles are sore.

Spots of cutaneous hyperæsthesia or anæsthesia are sometimes detected. In hysterical chorea the latter are very often present, and I have repeatedly found hemianæsthesia upon the left side.

The vision is affected, and, as a rule, errors in accommodation are found. So common is hypermetropia that it has been advanced as a cause of the disease, and a most absurd therapeutic course, which involves the use of glasses and operations, has been advised by one individual; but Dr. C. S. Bull exploded this theory, showing by statistics the frequency of hypermetropia in nonchoreic children and others. In debilitated subjects it is not difficult to get a history of dimness of vision, and sometimes we find pupillary alterations which consist usually in dilatation, and the pupils, as von Ziemssen has observed, are very sluggish.

Electrical response is somewhat altered. Rosenthal[2] found an increase in the electro-muscular contractility, with weak currents, in those patients who suffered from unilateral chorea. Galvanic excitability was pronounced, and cathodal opening with weak currents produced contraction. Benedikt obtained the same results, and also found that the electric sensibility is much exaggerated, and, when the electrode is applied to the cervical or dorsal region, eccentric pains in the limbs are complained of.

The presence of cutaneous eruptions is not uncommon. Eczema, as was originally shown by Fraenkel and myself, bears a very close relation to chorea, especially in children.

The movements, as a rule, cease when the patient sleeps, but this is sometimes not the case in pronounced or violent examples. Of one hundred and fifty-eight cases collected by Sée this was the rule, there being but six exceptions.

Dr. Robert Amory Hare[3] has conducted some investigations which go to show that monochorea is associated with elevation of temperature in the affected limb. Most of the conclusions were arrived at by simply estimating the degree of heat by applying the hand to the part or by the subjective complaints of the patient. When the thermometer was used a difference of four or five degrees was often found to exist between the two sides of the body.

The psychical changes in chorea have impressed such observers as Romberg, Skoda, and Marcé. This latter writer has referred to cases in which hallucinations were present, and feelings of dread were very pronounced; and Rosenthal mentions an old woman who was unusually garrulous and loquacious, and gave "utterance to savage cries." The hallucinations are most often presented in the half-waking state, and are, as a rule, visual. A case in which hallucination of an extremely interesting character was a feature is related by Ritti (*Union médicale*, 3me série, t. xix., p. 721, 1873), the subject being a girl aged nineteen. The hallucination depended upon derangement of all the senses, but principally of sight. She saw cats, bright lights; heard the voices of men close to her; perceived imaginary smells, tasted poisonous substances, etc.

Thore[4] reports a case of melancholia in a chlorotic girl, aged sixteen, who suffered from disturbed menses. Six weeks after the commencement of the melancholia she developed chorea which involved both extremities on the left side. She had auditory hallucinations at night, suicidal tendencies, more aggravated melancholia; and recovered, six weeks afterward, when the menses were re-established.

I have seen a number of cases in which mental perversion was conspicuous. Two cases in particular now occur to me. One was that of an old woman who had general and very severe chorea, and who for ten or twelve years was a confirmed chronic maniac. The other case was that of a young woman, aged twenty-five, who suffered from hysterical mania. In the first case the autopsy revealed very extensive cortical degeneration. I think, as a rule, that the form of mental trouble presented by choreics is that of excitement, and the psychical derangement is more common among adults than among children.

Some writers speak of a marked loss of memory; this I have never found except when the chorea was a symptom of dementia.

The urine of the choreic patient is often copious in amount, and, in those cases in which there is a rheumatismal complication, is apt to be loaded with the urates and phosphates. Sugar is occasionally found. Franque reports the case of a boy who suffered with chorea major, and whose urine contained sugar after each violent attack. In the intervals it was normal. This relationship, however, cannot be regarded as a matter of very great importance. Hanfield Jones, who has repeatedly examined the urine of these patients, thus tabulates the result of his urinary examination: "1. In tolerably severe cases, during the full sway of the disorder, the urine may be of high specific gravity, 1.030 to 1.040, contains an excess of urea; after crystallizing copiously with half its volume of nitric acid, deposits sometimes lithates, sometimes phosphates; its color is full, and on boiling with one-fourth its volume of muriatic acid it darkens extremely. 2. The total amount of urea and of phosphoric acid excreted in twenty-four hours may be greatly in excess. 3. In convalescence the specific gravity falls considerably, the color becomes paler, there is less darkening when the urine is boiled with muriatic acid, and the amount of urea and phosphoric acid may diminish to less than one-half. 4. The bodily weight increases during the period of convalescence. 5. It does not appear that the nervo-muscular agitation determines the increased excretion of urea, as the latter may be very marked in the paralytic form of the malady."

The relation of chorea to rheumatism and cardiac disease is one of the utmost importance. In 1839, Bright first insisted upon the recognition of the association of chorea with affections of the heart and pericardium, and in 1849 and 1850 Roth and Sée systematically described the rheumatismal origin of chorea. They, as well as Roger and Axenfeld, hold the following general views: Chorea may develop in the subject of acute articular rheumatism. The jactitations may appear in the course of an arthritic attack, but rarely when the temperature is high. The chorea may take the place of an attack of inflammatory trouble, and in the same subject the two conditions may alternate. In other cases the two diseases may coexist and be due to the same cause. Axenfeld speaks of the appearance of chorea in connection with the decline of the acute inflammatory symptoms. There is a species of antagonism in the vehemence of the maladies, says he, and the choreic movements, if present at all during the fever, are of the slightest kind, and limited to a few grimaces of the face.

The relation of chorea to heart disease is generally recognized to occur under three conditions, and these are tabulated by Axenfeld as: 1. When the chorea precedes the heart disease, a simple chorea without antecedent rheumatic trouble, the cardiac affection beginning from three weeks to three or four months after the commencement of the chorea. 2. When the cardiac trouble precedes the chorea, *e.g.*, when an attack of pericarditis is followed in from ten days to three weeks by well-established chorea. 3. When the chorea and cardiac affection begin simultaneously, or nearly so.

There are a variety of conditions which complicate the disease. Some of these are of an asthenic nature, and others are coincident diseases of infancy. Sometimes these intercurrent affections exercise a most remarkable effect upon the disease—cutting short the choreic attack. There may be, perhaps, a febrile attack of some intensity, during which the movements are increased until the fever attains the maximum intensity, when a diminution takes place. When the reaction ceases, the movements diminish or disappear. Sometimes such eruptive fevers as variola, when the force of the poison is exerted upon the nerve centres, produce an augmentation in the force and a continuance of the disease; in fact, it is changed perhaps from a simple functional affection to one of a chronic nature.

Chorea very often makes its appearance in pregnant women, usually during the early months of utero-gestation, and may last until a few weeks after delivery, or may become a chronic affection. I have seen many cases originating during the latter part of pregnancy, and lasting for many years; and I am inclined to regard the affection as a very grave one in many instances. In these cases I am of the opinion that some grave embolic lesion takes place, and that this is a result of the peculiar condition of the blood that exists in certain chlorotic subjects. In fact, I have several times witnessed the most serious accidents—cerebral venous thrombosis, and the like—which were due to some such blood state. The chorea of pregnant women is more apt to be bilateral, and the tongue is involved. This fact was first pointed out by Romberg. It is more common among primiparæ, and, according to Axenfeld, is quite likely to be associated with hysteriform and epileptiform convulsions, which lead to possible abortions. In one of Linck's cases the movements were worse when the patient was lying down. There is a lighter form than that of which I have spoken, which is quite common and begins during the early months of pregnancy, and the prognosis of which is not especially bad.

Hysterical chorea is rare; that is, the form described by Charcot and Bourneville, in which it is associated with the hysteric accès, and is manifested by rhythmical movements. I have not seen more than half a dozen of these cases; but it is by no means uncommon to find chorea developing in hysterical women, the disease, so far as the movements are concerned, differing little, if any, from the familiar disorder of infancy, only being more violent.

The subject of true hysterical, rhythmical chorea will for hours repeat, while apparently unconscious, a succession of movements, let us say of flexion and extension; and while sitting in bed she bows low, recovering herself rapidly, and goes through with this for hours at a time.

Adult chorea is an affection often associated with mental decay. The variety peculiar to old age (Chorée des Vieillards) is especially so, and it is frequently met with in association with dementia. I have encountered cases in which the disease lasted fifteen or twenty years, and in one instance the patient was upward of seventy years of age. The disorderly movements are quite general, involving not only the extremities and trunk, but the muscles of the face, so that the subject makes the most horrible grimaces. In such patients there is nearly always a history of cardiac trouble and old rheumatism.

Congenital idiots are very apt to present various disorders of motility, among which are automatic movements and chorea; in this instance the chorea probably being associated with cerebral hemiatrophy and difference in development between the two sides of the body.

Ireland[5] speaks of the association of insanity in children with a chorea which is curable. Electric chorea, which was originally described by Dubini, is a disease of endemic character, and it is manifested in a variety of ways: by rhythmical movements which last for weeks; by paralysis and atrophy of the muscles involved in the spasms; by local epileptiform convulsions, general at times; by headache and coma, by delirium, and, finally, by death. Its peculiar character gained for it the names myelitis convulsiva (Hörtel) and typhus convulsiva cerebralis (Frua). Delirium and head symptoms usually follow the first four weeks of the disease, and precede the coma (Radcliffe). The duration of the affection is about that of ordinary chorea.

Two very unusual forms of the disorder are known as tarantism and tigrétier. Both are varieties of chorea major, and are undoubtedly hysterical or imitative in character. The first, which, so far as I can learn, is unknown to-day, was supposed to be due to the bite of the tarantula. The development of the disease was marked by a period of depression and stupidity; and when the sound of musical instruments was heard, the victims leaped into the air and indulged in a wild species of dance, continuing it until powerless from exhaustion. During the epidemic sexual excesses of all kinds were rife.

The tigrétier, a disease of modern times, resembles very much the tarantism, and, in fact, both of these are in many respects like those forms of religious excitement which bring with them suspension of inhibitory control and great disorder of muscular movement. We are furnished with examples both in this country and abroad, and the convulsionnaires in France and the jumpers of Maine may be instanced.

Etiology.—Chorea, as a rule, is a disease of early life, and this may be said to be almost absolute in regard to chorea minor. The more severe affections, which include hemichorea, have, as a rule, some basis of cerebral change. The period, then, at which the disease is most common is between the ages of eight and eighteen; from eight to twelve it is very common. Congenital cases have been reported by Richter and Fox,[6] and Simon has met with it in children a few days old. Of 195 cases reported by Haven, 2 were said to be congenital, 11 were less than six years old, 92 between six and eleven, 58 between eleven and fifteen, 22 between fifteen and twenty-one, and 10 between twenty-one and sixty.[7] Heller[8] also presents a case. In adults we find that cases have been reported at all ages, and, as I have said before, even in advanced life. Some cases begin in childhood and continue through life, and others recur every year for several years and then subside. I have found, and I think my experience is borne out by the statistics of others, that the disease is most frequent during the spring or fall. I have repeatedly seen cases that commenced in October and continued until April or May, but, as a rule, under proper treatment the disease is not so protracted. In such cases I find often a history of eczema capitis and gastric derangements, and it is not uncommon to find the skin disease and the chorea in association. Sometimes the eczema takes the place of the chorea and marks the period of subsidence. So far as local climatic influences are observed, it would seem as if the disease belonged to cold or temperate countries. Axenfeld states, upon the authority of Rufz de Lavison, that it is unknown in Martinique, Guadeloupe, and other hot places; and I find that, while not unknown in our own Southern country, it is of comparatively infrequent appearance there. It is certain that the negro is exempt from the disease, as Dr. Mitchell has proved from inquiries he has specially made. I have never seen a case in a negro child. It is more common among the German and American children than among the Irish, so far as my statistics go, and the children of the poor are particularly liable.

Many authors agree as to the influence of heredity in cases which develop in adult life, and instances are on record in which the parents of the patient had been affected. Trousseau[9] and Hanfield Jones trace out the development in phthisical families, and Day calls attention to the fact that, among the Jews, it is very common and is often associated with epilepsy, or appears in the children of epileptic patients. It is by no means difficult in gouty families to learn not only that several children of the same family have been affected with chorea but that also the father or the mother had been a sufferer from the disease.

As to sex, it is commonly a disease of females, and the ratio is as three to one.

This is especially true when the subjects are between the ages of twelve and fifteen, the time of puberty. Of Pye-Smith's 136 cases, 98 were females and 38 males. Of 62 patients affected between the ages of six and ten, 47 were females, and the remainder males, while between the ages of six and fifteen, of the 106 cases 74 were females and the others males. In the cases in which the disease appears later in life there is a much greater preponderance of female patients, and this is true even of the anatomical form of the disease.

It is scarcely proper in this place to consider the variety of chorea known as post-hemiplegic, for this, after all, is a distinct affection, and the spasmodic movements are by no means pathognomonic. A degeneration of the pyramidal column, from whatever cause, will be quite likely to give rise to choreiform movements.

The influence of fevers, especially those of a zymotic nature, in the development of chorea, is important. Scarlet fever, measles, whooping-cough, and diphtheria sometimes leave after them a most intractable chorea, which oftentimes becomes a chronic affection.

Barclay, Bernheim, and others speak of typhoid as a cause or complication.

Onanism is mentioned as a cause, but I do not attach much importance to this statement, although it appears to find favor with the Germans.

Overstudy has undoubtedly much to do with its development. Some years ago I found by a careful system of inquiries, instituted by means of printed tables, that nearly twenty per cent. of the public school children of New York suffered from some choreiform trouble, which varied from simple limited twitchings to well-marked chorea. Dr. J. Crichton Browne, in the report of an investigation which he had made (see "Report upon Overpressure of Work in Public Elementary Schools," London, 1884), says that while he found much nervous motor trouble, he is of the opinion that chorea is not as common as here, but he admits that his paucity of findings may have been due to the fact that children were taken away from school as soon as affected.

Saturnine chorea may manifest itself in suddenly developed convulsive movements of the limbs. Tanquerel speaks of it ("Lead Diseases, a Treatise," etc., by L. Tanquerel des Planches, American translation, 1850, p. 288), the "first form of the convulsive variety," as follows: "The face, or one side of it only, one or several limbs, are agitated by rapid convulsions analogous to those produced by electric shocks. Instead of this effect all the parts may be struck with permanent contraction, remaining a longer or shorter time without interruption." It is usually a form of trouble connected with cerebral diseases of a grave type, and is the precursor of the rupture of a blood-vessel.

The association of chorea with epilepsy is occasional, and, when found, is an affection of long standing. I have met with it frequently in children, and almost without exception the attacks of epilepsy involved the limbs of one side of the body; in fact, there were a hemiepilepsy and hemichorea in association. In two cases there were general convulsions, beginning unilaterally in association with hemichorea.

Chorea is occasionally of traumatic origin, and is then, as a rule, dependent upon some grave cerebral lesion or meningeal irritation. Chauveau has reported a case that was dependent upon a cicatrix.

Kinnicutt and Heinemann have pointed out the relations of chorea to certain states of malarial poisoning.

A form of toxic chorea that is observed in adults is the direct result of *tobacco.* It is usually general, but may be confined to the muscles of the face. I have seen many cases of this disorder in subjects who used tobacco to excess. The movements were found in association with vague hyperæsthesiæ, or rather dysæsthesiæ, consisting of a "tightness" or a "feeling of tension" of the skin of the face and head, with palpitation and gastric disturbances—manifestations which subsided under the use of hypophosphites and upon the discontinuance of the habit.

In one boy, who was addicted to the practice of cigarette smoking, the disease was entirely due to this bad habit. In all of these cases the fæces were often redolent of decomposed nicotine.

Intestinal irritation is a most important cause of chorea, whether such irritation be from intestinal worms or from undigested food. Cases in which the expulsion of lumbricoides was followed by cure are numerous. Tardieu reports a case in which a sudden cure followed the expulsion of eight lumbricoides. I have frequently met with examples of the disease in which immediate relief was afforded after the rectum had been freed from a ball of pin-worms by a free injection of quassia or a saline enema. It rarely happens that the source of intestinal irritation is a Tænia solium, but, strange to say, children are sometimes the subjects of chorea from such a cause. Hanfield Jones speaks of a boy, nine years old, who was sleepless for four days and nights, who was in a state of constant motion, whose lips and teeth were covered with sordes, and who presented every appearance of collapse. A dose of oil of male fern brought away a tapeworm seven yards long, and in a few days the patient rapidly convalesced. I have reported elsewhere a case of this kind, and in this as well as in some other cases of chorea the distinguishing features are the sudden development and very violent and general character of the disease.

The influence of *imitation* and *fright* as exciting causes is supposed to play a very great part in the genesis of the malady.

In the epidemic form of the disorder there are many historical examples. The danger of association of healthy with choreic children has been, I am convinced, very much exaggerated. When the disease develops under these circumstances, the victims are usually hysterical subjects. In a child of weak nervous system a sudden fright may undoubtedly cause much mischief.

Strange considers the influence of two forms of fright (*British Med. Journal,* July 16th, 1881, p. 69), and he believes that in two-thirds of the cases it is the exciting cause. "Fright may operate in various ways, some simple, some more continuous and complicated. It need not be sudden, though that is generally the case. There is a kind of fear or fright to which children are exposed for long periods of time. Ill-tempered parents, especially the mother, may keep a child in perpetual trepidation and dread of punishment for unavoidable disasters. Again, the coming home of a drunken father must often be a source of continual terror to a delicate and sensitive girl. Ghost stories and foolish threats of 'Old Bogies,' and the like, so constantly used by ignorant mothers and nurses, need only to be mentioned to be severely reprobated."

The appearance of chorea in children who have been improperly fed is not always regarded with the importance it should be. An excessive meat diet is often responsible for this as well as other neuroses, notably epilepsy and hysteria. In these cases there is very often a history of broken sleep, night terrors, incontinence of urine, and not infrequently somnambulism.

The Pathology of chorea has been considered by a number of English and continental observers, the former adhering to the theory of a cerebral origin of the affection. Todd, Stenhouse and Kirkes, Broadbent, Ogle, Tuckwell, Hughlings Jackson, and Bastian all favor the theory that it is an embolic disease, and that the corpus striatum is its seat. Though Todd was the first to point out this probable origin of the disease, starting from the standpoint of the unilateral spasm and hemiparesis, it was not until 1870, or thereabouts, that Kirkes stated that chorea is the result of irritation produced in the nerve centres by fine molecular particles of fibrin which are set free from an inflamed endocardium and washed by the blood into the cavities of these centres. Appreciating the important relationship of the middle cerebral artery to cerebral nutrition, the other investigators named look upon the corpora striata as the region most often affected. Ogle, Tuckwell, and others have found embolic plugging. Aitken believed the optic thalamus to be affected as well, but it would appear that in the cases under consideration there were sensory alterations.

A variety of experiments have been made by Raymond and other French investigators.

Raymond experimentally caused chorea in dogs by wounding the internal capsule and optic thalamus, producing chorea of the opposite side.

Rosenthal[10] experimented, for the purpose of producing embolic occlusion, by injecting pollen into the left internal carotid of a choreic dog in whom the movements were most active in the right foreleg. The result of the injection was that the dog became powerless to change his position. Despite the abolition of voluntary movements, however, violent choreic convulsions occurred in the anterior limbs, in the eyes and tail, and continued for two days, until the death of the animal took place. Autopsy: Encephalitis of the left anterior lobe, softening of the left corpus striatum, embolism of the left middle cerebral artery, etc. The conclusion arrived at was that the abolition of function of the motor ganglia was followed by increase of choreic movement and irritation of the coordination centre.

Other investigators—among them Chauveau,[11] Carvaille, and Bert—operated upon choreic dogs; they cut the cervical cord and determined that the choreic movements were not dependent upon any influences emanating from the cerebrum or cerebellum. A section made lower down in the dorsal region in two other dogs resulted in diminution of the movements in the tail and legs. They concluded, therefore, that chorea minor was a spinal affection.

Le Gros and Onimus[12] made further experiments, and were also of the opinion that chorea was a disease of the cord. Excitation of the posterior column exaggerated the movements, and freezing this part of the cord produced a diminution in their intensity. The movements were not diminished by section of the posterior root zone, but only by the partial section of the posterior columns and horns. These observers concluded that the seat of the chorea was in the cells of the posterior horns, or in fibres connecting them with the great motor cells.

Numerous post-mortem examinations have been reported, the most important of which are those of Meynert and Ellischer,[13] who found changes in the peripheral nerves as well as cerebral lesions.

The English authorities have made many autopsies, and their researches have revealed obstruction of the middle cerebral and smaller cerebral arteries, usually on the left side of the brain.

Bastian found, in one case of bilateral chorea, embolic plugging by an aggregation of white corpuscles, obliteration of small vessels in the corpora striata, serous effusion in the ventricles, etc. Hughes collected fourteen fatal cases in which the meninges were either congested or pale. There were effusions and subarachnoid and ventricular adhesions of the dura to the skull; in fact there was nothing distinctive about the findings. In eight of these cases the spinal canal was opened, and in these cases the cord was found to be perfectly healthy, as were also the membranes. In one there was slight congestion. In the other four there were adhesions of the arachnoid of ancient date, and softening of the posterior columns and gray matter generally. In one case softening was found at the level of the third or fourth dorsal vertebra.

At best these particular results simply show that fatal chorea may be found with cerebro-spinal textural alterations of inconstant character.

The observations of a few English writers, among them Bastian, are of great value in pointing to the corpora striata as the chief seat of trouble.

The continental investigators have done much more accurate work and have shed great light upon the pathological anatomy of the disease.

Meynert,[14] especially, and Schultze[15] have both ably investigated fatal cases. The former found degeneration of a large number of cells of the cortical substance of the brain, some being swollen and the others shrivelled. Those of the third frontal convolution were involved quite extensively, and so also were those of the ganglia. There were general connective-tissue thickening, and proliferation in the motor tracts of the brain and cord.

The morbid appearances found by Ellischer included very extensive degeneration of the nerve elements of the corpus striatum, hyperplasia of the connective tissue, and proliferation of the nuclei, especially of the lenticular nucleus; the walls of the blood-vessels were also found to have undergone a thickening. At the same time the cord was involved, the posterior columns being the seat of some sclerosis in the gray matter, which was hyperæmic; and there was a decided nuclear proliferation in the gray substance adjacent to the cells, which were more or less diseased, they being pigmented and destitute of nuclei. Besides these changes there was a sclerosis of the peripheral nerve fibres, together with a certain amount of destruction of the ultimate nerve filaments. Dana[18] (1898) practically agrees with certain observers and has found degeneration of nerve cells, perivascular dilatation, and infiltration of the cells of the intima of the small arteries; also fibrinous deposits on the walls of the heart.

As to PROGNOSIS, we have to consider the question of duration of the immediate attack, its probable recurrence, and the possibility of a fatal termination. I have already called attention to the two first, and I shall simply add that chorea minor is usually a simple and curable affection. In adults this is not the case, for when no other cause can be ascertained, it is unhappily true that the affection is too often indicative of some such gross cerebral disease as tumor or sclerosis, or is a sequence of arterial rupture. I have seen many cases of the simple affection in chlorotic young women, in fact in women of thirty to forty, which was readily curable; so even this rule has its exceptions.

The danger in fatal cases arises from exhaustion, from the debility caused by the constant excessive motion, and by attendant insomnia. In febrile cases the prognosis is decidedly bad if anything like a typhoidal state supervenes.

Numerous fatal examples have been reported. Griswold[16] relates a case which proved fatal in sixteen days, and Ogle[17] brought forward sixteen other cases.

Haven, of Boston, has made some very interesting investigations, and has analyzed 200 cases of chorea. From his table it would appear that the average duration of the disease, in 25 such cases as he could follow up, was 94.5 days. In others it was 77 days, when arsenic was used.

Gray and Tuckwell have also gathered statistics in a number of cases when no treatment was given, and the average duration was from 72 to 76 days in different sets of cases. It is not uncommon to find cases which recover in six weeks, and sometimes, under the use of ferruginous tonics, the period may be much shorter.

The tendency to relapses is quite common; in fact, Haven found that there was 1 relapse in 22 cases, 2 in 4, 3 in 2, 4 in 1, 5 in 1, and 7 in 1, and 14 of these recurred in the first six months of the year. Von Ziemssen refers to the fact that recurrences are most common at puberty. Of 33 cases of chorea the notes of which I have kept—and the number would have been much larger were it not for the fact that many were observed at dispensaries, where the attendance is so irregular and floating—I found that in 40 per cent. of the cases there were 2 relapses.

The residual paralysis is sometimes, though rarely, quite lasting. If a hemichorea exist for a year, it is quite likely to be associated with some loss of muscular substance. In one of West's cases—a girl—it was found, three months after the movements had ceased, that the left arm was half an inch smaller than the right. In another patient—who had kept her hands clenched for a long time—there was wasting and contraction.

The **Diagnosis** of chorea should be simple enough, if we throw out of consideration those cases of organic origin, the so-called "post-hemiplegic chorea." The movements themselves can hardly be confounded with any others. They are coarse, jerky, and irregular, and in no sense rhythmical. The same cannot be said of the movements observed in post-hemiplegic chorea, in which, besides eccentric jactitations, there is usually more or less tremor. The movements of chorea may in simple cases (I may say always in chorea minor) be controlled, in part or wholly, by the exercise of the will. Embarrassment and diversion of attention seem to aggravate the intensity.

The age of the subject is also a determining factor. Those forms of degeneration of the brain or spinal cord in which hyperkinesis is a symptom are very rare in children, the exception, perhaps, being cerebral hypertrophy and hemiatrophy; and here we find errors in development and other concomitant symptoms which render diagnosis quite simple.

In paralysis agitans we have an affection which resembles to some extent certain varieties of adult chorea. We find festination, associated movements, no aggravation by attempt at control, and a "fineness" of the spasms which can hardly be called choreic.

In the diagnosis of the particular cases much depends upon our ability to determine the probable nature of the chorea itself; whether it be due to eccentric irritation, to anæmia; whether it be a sequence of one of the zymotic diseases; or whether it be a symptomatic affection, the result of some form of tissue change. These things are important when we come to predict the course of the malady. It will readily be seen how much credit may be gained by recognizing the true nature of a chorea dependent upon intestinal worms or other irritative causes, and promptly curing the same by expulsion of the irritating agents. The connection of the disease with some affection of the heart is also most important to recognize.

The **Treatment** of chorea has probably received more attention than that of any other nervous disorder, and the list of remedies, good, bad, and indifferent, is very long. As I have said, there is very little difference between the duration of the malady in those patients for whom the expectant treatment is ordered, and the duration in the case of those who are subjected to a rigorous course of medication of the orthodox kind. In the practice of medicine, masterly inactivity is not always the most prudent method of procedure, but in chorea minor I would counsel the simplest treatment possible. Of the vast horde of remedies, I think we can discard all but three or four, and I will name them in their order of usefulness: (1) Arsenic; (2) strychnine; (3) iron; (4) the fats.

There is a second list of remedies which are employed for the purpose of reaching special conditions, and among these I may mention heat and cold, anthelmintics, sedatives, the coal-tar products, etc.

If we do use any of the remedies of the first order, it must be freely and with the idea of getting their full physiological effects; especially is this true of arsenic and strychnine. In children the dose of the former should be rapidly increased until slight œdema becomes visible below the eyes, while the good effects of strychnine are obtained only when there is complaint of tension of the back-leg muscles. For reasons of safety as well as on account of greater efficacy, a bulky solution of strychnine is recommended in preference to drops or granules. In combination with the syrup of the iodide of iron, the latter drug is of especial service in the anæmia of chorea. To this mixture may be added digitalis, especially in many cases in which cardiac asthenia is a feature. The French writers favor the division of chorea into many forms with relation to the etiological factors. When such forms are clearly made out, of course it becomes our aim to direct special treatment to the individual cases. In those forms with *rheumatismal* history, the salicylate of soda, the tincture of cimicifuga racemosa, sulphur and vapor baths and alkalies, are of great service; hysterical cases are most helped by the valerianate of zinc, cypripedin, or cannabis indica. In many cases the removal of an ulcerated wisdom tooth is sufficient to effect the disappearance of a violent chorea, and when intestinal worms exist, we are to turn to turpentine, kousso, or santonin.

Should the movements be sufficiently violent, as they often are, to necessitate the use of restraint, I know of no better remedies than hyoscyamine or chloral hydrate. Of the benefit of calabar bean in such cases, I have little to say. It has never been of the slightest service in several cases in which I have tried it, and I may say the same thing of belladonna. Axenfeld recommends opium in large doses, but he wisely cautions those who administer it to children. Gery and Fuster recommend the repeated use of chloroform—in inhalation—several times a day.

In some cases the remedies cited above may be used hypodermically, but, as a rule, this is an unnecessarily painful mode of treatment. Arsenic has been used in this way.

Four or five drops of Fowler's solution may be injected daily in the affected member; and by Radcliffe, Eulenburg, and others, it is said to act more quickly than when administered by the stomach.

The use of cold is occasionally of great benefit to the choreic patient. The application of the ether spray to the entire spine every day, for ten or fifteen minutes, or the application of cold by means of the ice-bag, is excellent, especially in violent cases. I have of late applied the needle douche, using several gallons of water.

It is of the utmost importance that the patient should be kept quiet, and that muscular exercise should be forbidden. A few hours' seclusion daily, in a dark room, works wonders, and at other times the patient should be made to assume a recumbent position, if possible.

There is no other nervous disease which is helped so much by proper diet as this. Fats are essential, and a liberal administration of milk and cream as well as fresh butter is highly recommended. Good substantial soups, raw meat, and condensed nitrogenous nourishment should be provided to the exclusion of everything else which simply satisfies hunger or gratifies the capricious appetite of the patient. Sea air is of immense service, and sea baths, if not too wearisome, are to be advised. Still-water bathing, of course, is to be preferred to surf bathing.

Moral treatment is of great value in many cases. West, whose sensible ideas of treatment I have always adopted, when possible, calls attention to the emotional perversion in choreic children, and speaks as well of the hebetude and weariness of mind, which seem to disappear with the movements. He considers moral therapeutics inapplicable to those cases of partial chorea which sometimes, though not often, last through life. The treatment should consist in removing mental strain, abridging study, and instituting a regular life and proper habits, and in building up the child's will power. The consciousness of the child, in regard to his infirmities, should not always be awakened, except when it is clearly a bad habit and not the result of disease.

Allan McLane Hamilton.

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CHORION.—The chorion is the outermost of the membranes which surround the embryo, and plays a most important part in its development, as it soon comes in contact with the decidua and takes an active part in the formation of the fœtal portion of the placenta.

According to Minot, "the chorion is the whole of that portion of the extra-embryonic somatopleure which is not concerned in the formation of the amnion." This definition is undoubtedly correct for a large number of animals, but recent investigations render it doubtful whether it applies to man; as all of the earliest human ova which have yet been described (from the latter part of the first and the beginning of the second week) possess a distinctly formed chorion before there is any apparent differentiation into somato- and splancho-pleure.

According to Kollmann, it is more than probable that a distinct chorion is formed by the time the ovum reaches the uterine cavity, but unfortunately so young a specimen has not as yet been observed.

Theoretically, the chorion represents the outer layer of the blastodermic vesicle, and accordingly its epithelial layer must be derived from the primary ectoderm of the ovum. The earliest human ova which have yet been described are those of Peters and Graf Spee, in both of which the chorion is perfectly developed, while the embryo is in a very rudimentary condition.

Peters obtained his ovum at an autopsy upon a woman who committed suicide three days after missing a menstrual period, and he believed that it was not more than three or four days old. From his description, however, it appears to be somewhat older, but certainly not older than ten days. The ovum measured 1.6 x 0.8 x 0.9 mm. in its various diameters, and is therefore the smallest which has thus far been reported. It was embedded in the decidua and lay beneath its surface, having apparently burrowed its way through the epithelium; and it gives most important information concerning the mode of implantation of the ovum and the development of the decidua reflexa. The ovum presented a well-developed chorion which consisted of two layers: an inner layer of mesoderm and an outer layer composed of many layers of epithelial cells, which Peters designated as trophoblast.

Protruding from the surface of the chorion were a few elevations, whose interior was filled with connective tissue, representing the earliest stage of villous formation. The trophoblast was arranged in many layers and surrounded the connective tissue of the chorion as a distinct capsule. It was made up in great part of round or polyhedral cells, which stained deeply and presented distinct vesicular nuclei, between which were a few masses of protoplasm which showed no tendency to divide into individual cells, through which were scattered irregularly shaped, darkly staining nuclei. The trophoblastic cells were apparently growing very rapidly, and had opened up dilated capillaries in the surrounding decidua, so that numerous small cavities were formed, which were lined by trophoblastic cells and filled with blood, and which probably represent the earliest stages in the formation of the intervillous circulation (Fig. 1291).

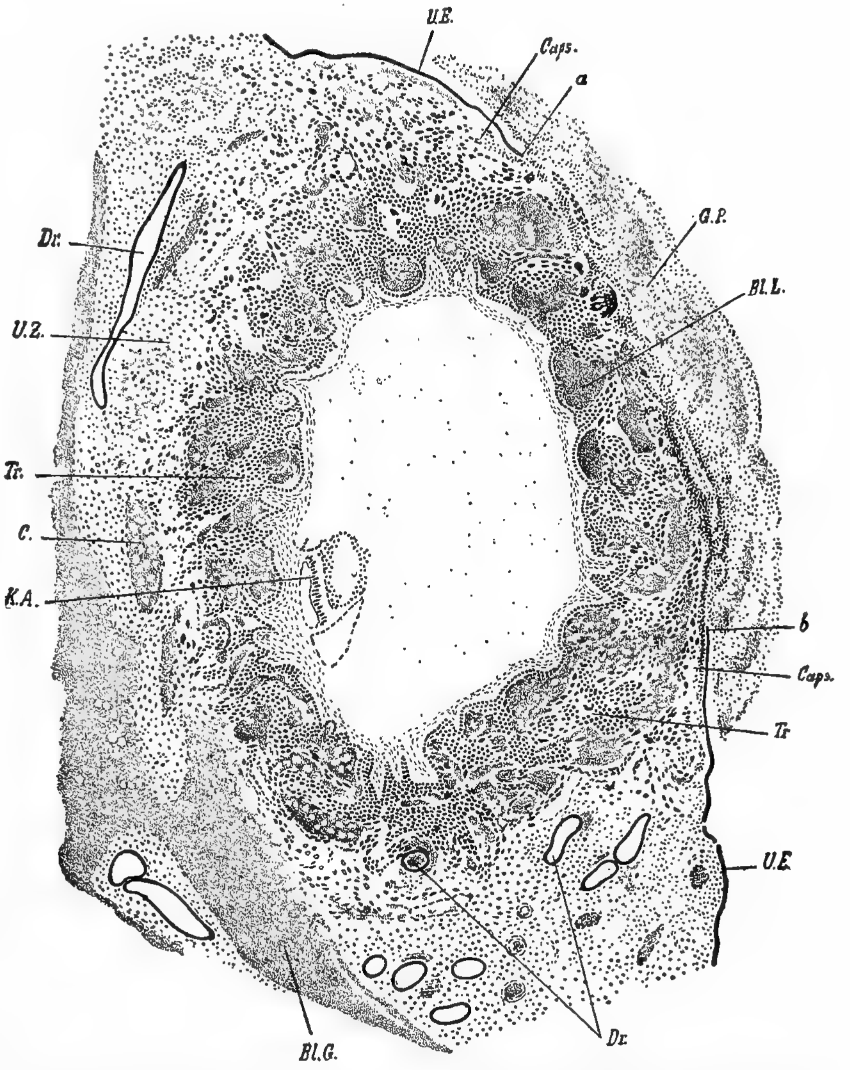

FIG. 1291.—Peters' Early Ovum. *U.E.*, Uterine epithelium; *Bl.L.*, lakes of blood; *Caps.*, decidua reflexa; *G.P.*, "Gewebspilz"; *Dr.*, uterine glands; *U.Z.*, decidua vera; *Tr.*, trophoblasts; *C.*, capillaries; *K.A.*, beginning embryo; *Bl.G.*, large blood-vessels; *a–b*, point of entrance of ovum.

Spee's embryo was cast off from the uterus as an oval body, 9 x 6.5 mm., and consisted of a vesicle which enclosed the beginning embryo. In this specimen the chorion was definitely formed, and consisted of an epithelial and a connective-tissue layer, and distinct villi arose from one portion of its exterior (Fig. 1292).

Very early ova have likewise been described by Reichert, Mall, and Leopold, the first two having been discharged from the uterus, while Leopold's ovum was still in contact with the uterine wall and surrounded by the decidua reflexa. The specimens of Leopold and Mall presented well-developed chorions, with villi over their entire periphery; while in Reichert's specimens they were limited to the equator of the ovum (Fig. 1293).

In all early ova which have thus far been described, the chorion consists of two layers: an outer epithelial and an inner connective-tissue layer. We have already indicated that the epithelial layer is derived from the ectoderm of the blastodermic vesicle, but it is not so easy to explain the origin of the connective-tissue layer. In all the early ova, the amnion presents a very rudimentary appearance; and it is therefore improbable that the connective tissue of the chorion is derived from the somatopleure, in the same way as in many of the lower animals.

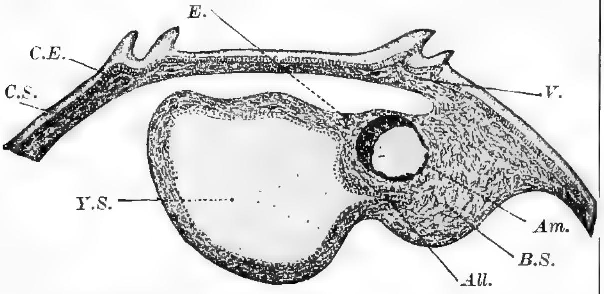

FIG. 1292.—Section through Spee's Early Ovum. No. 9 Zeiss. 6 mm. Magnified 24 times. *Am.*, Amnion; *All.*, allantois; *B.S.*, Bauchstiel; *C.E.*, chorionic epithelium; *C.S.*, chorionic connective tissue; *E.*, beginning embryo; *V.*, villi; *Y.S.*, yolk sac.

In its earliest stages the chorion consists of a membranous sac composed of two layers, ectoderm and mesoderm, and includes within it the beginning embryo. In all the specimens which have thus far been observed, a greater or lesser number of villi arise from the external surface of the chorion. At first they are purely epithelial in character, and in Peters' ovum are represented by mere projections of trophoblastic cells. At a little later period, however, the centre of the villus becomes filled with connective tissue, which is continuous with the inner layer of the chorionic membrane. The youngest chorion which I have examined was obtained from a two weeks ovum in the possession of Dr. Mall. Fig. 1293 gives a very good idea of its structure and shows that it is made up of two parts: (1) a chorionic membrane, and (2) the villi which spring from it.

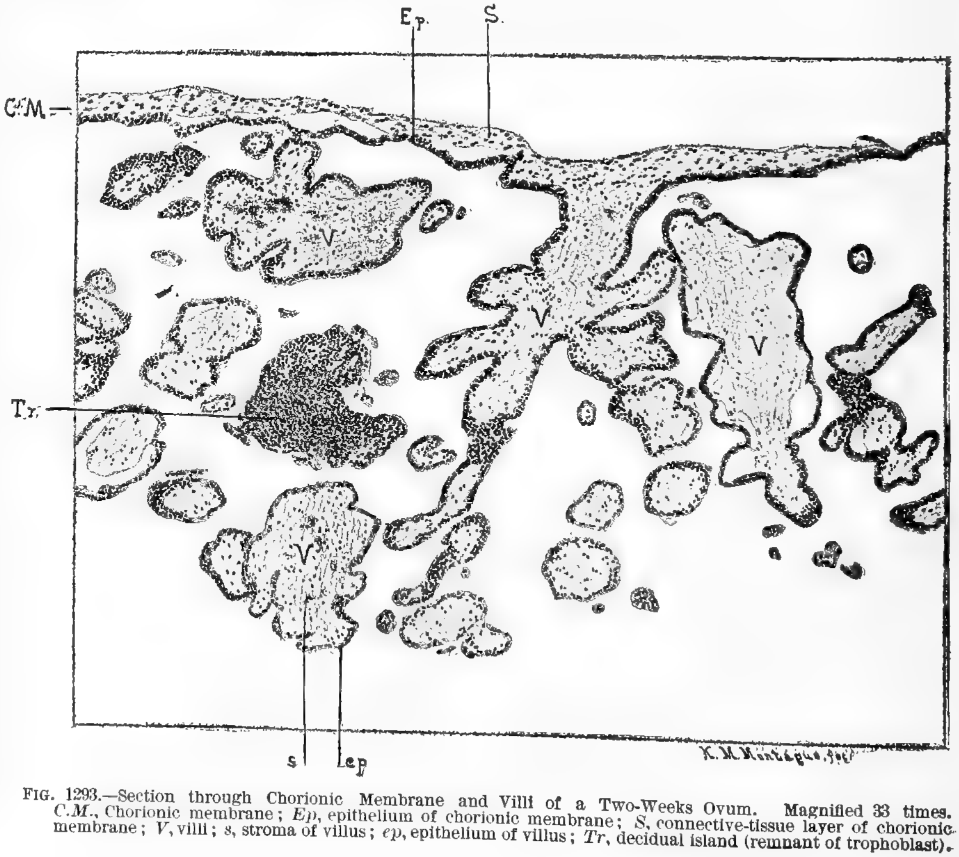

FIG. 1293.—Section through Chorionic Membrane and Villi of a Two-Weeks Ovum. Magnified 33 times. *C.M.*, Chorionic membrane; *Ep*, epithelium of chorionic membrane; *S*, connective-tissue layer of chorionic membrane; *V*, villi; *s*, stroma of villus; *ep*, epithelium of villus; *Tr*, decidual island (remnant of trophoblast).

The chorionic membrane is composed of an inner layer (toward the embryo) of connective tissue, which is made up of branching and star-shaped cells, which are separated from one another by a large amount of mucoid intercellular substance, in which no trace of vessels can be observed. Its exterior is composed of epithelial cells, which are arranged in two layers: an inner layer consisting of distinct cuboidal cells with round vesicular nuclei, and an outer layer made up of a band of protoplasm which is not divided into individual cells, and scattered through which are numbers of irregular-shaped, darkly staining nuclei.

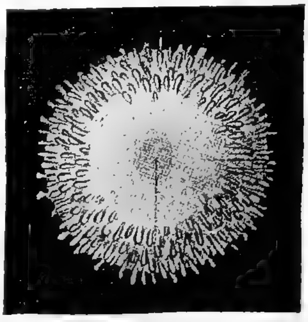

FIG. 1294.—Reichert's Ovum. Magnified six times.

The villi are arborescent structures which project from the outer surface of the chorionic membrane, and consist of a single trunk or stem, from which numerous branches are given off at something less than right angles. The tips of some of the larger branches extend down to the decidua, and serve to fasten the chorion to it; but the great majority of the smaller branches, after branching repeatedly, end freely and project into cavities which are filled with blood, and which constitute the intervillous spaces of the placenta. I do not believe that there is any evidence of anastomosis between the branches of the different villi, any more than between the branches of individual trees in a park.

The villi consist of a connective-tissue core which is continuous with the connective tissue of the chorionic membrane, and is covered by two layers of epithelium, just as is the chorionic membrane. None of the villi contain blood-vessels at this period. In several places the epithelium covering them appears to be arranged in many layers, and this is due either to tangential sections through the periphery of a villus or to the formation of epithelial buds, which represent the earliest stage in the formation of new branches. At one point in the section (Fig. 1293, *Tr.*) there is a mass of cells which present a distinctly epithelial appearance. Such structures are usually designated as decidual islands, and are supposed to be due to sections through decidual septa, which extend from the decidua toward the chorionic membrane. But in view of the marked similarity of the cells composing the mass to those which cover the villi, I am inclined to believe that they represent a remnant of trophoblast rather than a section through a decidual septum.

At a little later period the chorionic membrane becomes vascularized, and large numbers of vessels, both arterial and venous, are found just beneath its epithelial covering, branches from which extend into the villi, where they break up into a capillary network. These vessels are derived from the umbilical arteries and veins of the fœtus, and do not communicate with maternal vessels. Their arrangement is clearly shown in Fig. 1295.

It is not definitely known how the vessels first make their way to the inner surface of the human chorion. In many of the lower animals it has been definitely demonstrated that they are derived from a vesicular allantois, which grows out from the embryo between the amnion and chorion, and eventually applies itself to the inner surface of the latter. In man, however, this does not occur, as the extra-embryonic portion of the allantois is very rudimentary and does not assume a vesicular form, being merely a small epithelial duct which extends from the intestinal tract for a short distance into the umbilical stalk (Bauchstiel) (Fig. 1292).

The Bauchstiel is a prolongation of the caudal end of the embryo, and serves to connect it with the inner surface of the chorionic membrane. It contains the umbilical arteries and veins, and at a later period becomes converted into the umbilical cord.

At a still later period of development the chorionic membrane takes on a more complicated structure, and we are indebted to the classical article of Langhans for our first definite information concerning it. He stated that it was made up of four layers: gelatinous (Gallertschicht), fibrillar, vascular, and epithelial. The gelatinous is the innermost layer and lies in apposition with the connective tissue of the amnion. It is composed of mucoid connective tissue, analogous to the Whartonian jelly of the umbilical cord. External to this is the fibrillar layer, in which the connective-tissue cells are more abundant and have become more fusiform in shape, and are arranged in such a way as to give the tissue a distinct fibrillar appearance. External to this is the vascular layer which is composed of loose connective tissue, which surrounds large numbers of blood-vessels, both arteries and veins; while the outermost layer is composed of epithelial cells. The epithelium outside of the placental site consists of several layers of round or cuboidal cells, which stain palely with the ordinary reagents, and present distinct vesicular nuclei with a faint chromatin network, which readily stains with the ordinary dyes. At the placental site these cells are covered by a layer of syncytium, which is lacking in other parts of the chorionic membrane.

The above-mentioned cells were designated as the "Zellschicht" by Langhans, who considered that they were of connective-tissue origin. Further study, however, convinced him that they were epithelial cells and derived from the ectoderm of the ovum. This layer of cells has given rise to a great deal of misconception, and many observers believe that they are decidual in origin, having been designated by Kölliker as the decidua subchorialis, and by Winckler as the "Schlussplatte" of the decidua.

For the first few months, the entire periphery of the chorion is covered to a greater or less extent by arborescent and branching villi, except in Reichert's ovum, in which they were limited to its equator. Almost immediately after its formation the chorion becomes completely enclosed by a capsule composed of the decidua serotina and reflexa, from which it is separated by the growing villi, and the spaces thus formed become filled with maternal blood and constitute the intervillous spaces. This condition is very clearly demonstrated by the two ova which Leopold has lately described in his Atlas.

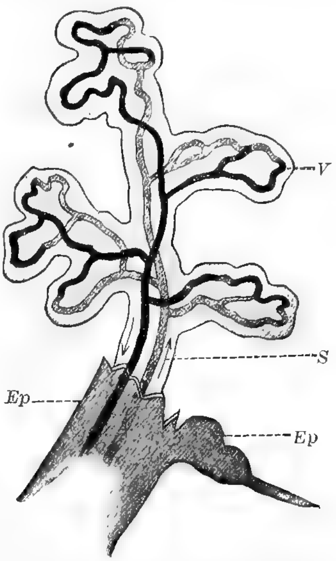

Fig. 1295. — Chorionic Villus from Full-Term Placenta. Highly magnified. (After Kollmann.) *Ep*, Epithelial covering; *S*, stroma of villus; *V*, vascular loop.

After a few months, however, the villi which are in contact with the decidua reflexa begin to atrophy, so that within a short time the chorionic membrane and the decidua reflexa come to lie in intimate contact, with only the degenerated remains of the villi separating them; while the villi which are in contact with the decidua serotina continue to grow and become larger and larger and give rise to the fœtal portion of the placenta. At this period we distinguish between the chorion læve and the chorion frondosum, the latter being the portion which takes part in the formation of the placenta. For further particulars concerning the structure of the placenta, the reader is referred to the article upon that subject.

The villi of the chorion frondosum, as we have just indicated, increase rapidly in size and complexity, and give off numerous branches which form the bulk of the placenta. But it is not probable that the primary villi increase in number after the first few months, the increased thickness of the placenta being due to the branching of the pre-existing villi; just as a row of trees, when first planted, is represented by a number of isolated stems, which at a later period are converted into large trees with myriads of branches and twigs. This fact has been strikingly demonstrated by de Loos, who has shown that one can roughly estimate the age of a placenta by the shape and size of its villi. Sections through a young placenta show a few large villi with comparatively few branches; while in a more mature placenta one sees large numbers of small branches, which become smaller and smaller as the placenta becomes older.

The stroma of the villi likewise undergoes marked changes as the placenta becomes older. In its early stages it is distinctly mucoid in appearance, and is made up of a small number of stellate cells which are separated by a large amount of mucoid intercellular substance. As the villi become older their stroma becomes denser, and the cells are more abundant and more fusiform in shape, so that at the latter part of pregnancy it presents a distinctly fibrous appearance.

Coincident with the changes in the stroma the villi become more vascular, and in the second half of pregnancy contain distinct vessels, many of which attain considerable size, the large arteries being surrounded by thick walls

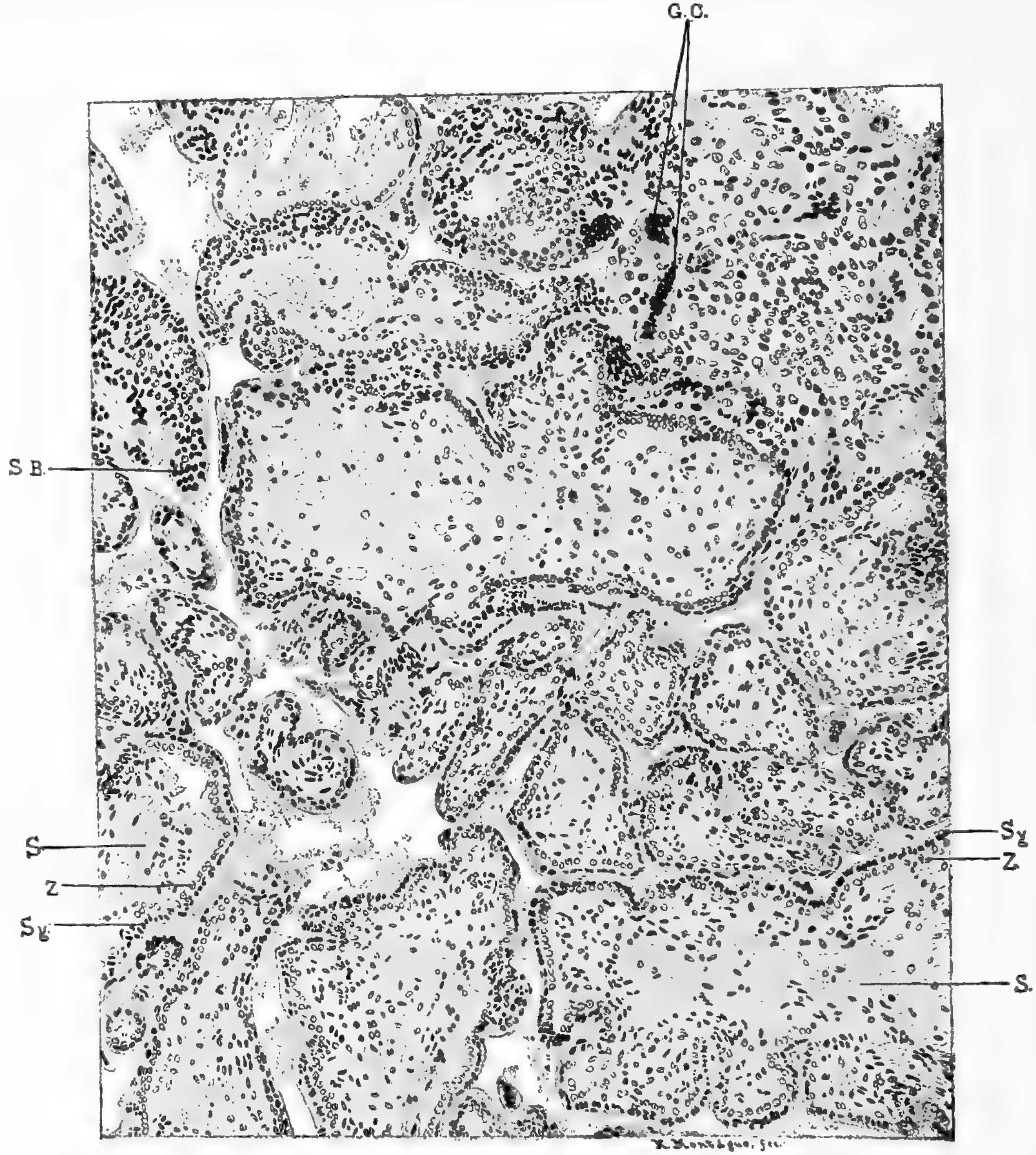

FIG. 1296.—Section through a Three-Months Placenta, Showing Structure of Chorionic Villi. Magnified 110 times. *S*, Stroma of villus; *Sy*, syncytium; *Z*, Zellschicht; *S.B.*, syncytial bud; *G.C.*, so-called placental giant cells.

The epithelium covering the chorionic villi was first described by Dalrymple in 1842, and we now know that it is arranged in two layers: an outer, which consists of a band of protoplasm, which is not divided into individual cells, and to which the term "syncytium" has been applied; and an inner layer of definite cuboidal cells, which were designated by Langhans as the "Zellschicht." The protoplasm of the syncytium presents a coarsely granular appearance, which on careful examination is seen to be due to the presence of vacuoles of varying size. The nuclei which are scattered through it are irregular in shape and contain a thick chromatin network which stains deeply with the ordinary dyes. The Zellschicht is composed of a single layer of distinctly cuboidal cells with vesicular nuclei. Their protoplasm stains very lightly and thus contrasts markedly with that of the syncytium; while the nuclei have a very delicate chromatin network, and therefore stain far less darkly than those of the syncytium.

These two layers are readily recognized during the first half of pregnancy, and are clearly shown in Fig. 1296, which represents a section from a three-months placenta. As the placenta grows older, however, the inner layer gradually disappears, so that in the last months almost all trace of it is lost, when the villi are covered only by syncytium. The failure to recognize this fact was the cause of a great part of the discussion concerning the arrangement of the chorionic epithelium, and only recently has it been generally recognized; but it is now universally admitted that two layers of epithelium can always be distinguished in the earlier months, and only one in the latter months of pregnancy.

The syncytium is not always arranged in a single layer, and several layers of nuclei may be observed in many places, while distinct buds of syncytial tissue frequently project from the surface of the villi and represent an attempt at branching. In microscopic sections, variously shaped masses of syncytium, containing many nuclei, are frequently found lying free in the intervillous spaces, and are frequently described as placental giant cells. The examination of serial sections will, however, always show that they are cross sections through such buds, or are due to tangential sections through the tips of the villi.

The term syncytium was introduced by Kossmann, though its characteristic features were described by Kastchencko in 1885, who designated it as plasmodium.

The chorionic epithelium has been the subject of marked controversy ever since it was first described, and various attempts have been made to explain its origin. The earlier writers supposed that the villi grew down into the uterine glands and obtained an epithelial covering from them. But Langhans, in 1877, was the first observer definitely to describe two layers, and, as we have already indicated, designated the inner layer as Zellschicht: At that time he believed that it was derived from the stroma, while the outer or syncytial layer represented the fœtal ectoderm. A few years later, however, he modified his opinion and stated that both layers were epithelial in origin. Langhans' views were soon adopted, and Minot, Kastchencko, and many other investigators recognized the existence of two layers, and considered that they were ectodermal in origin, and that the inner layer was derived from the outer.

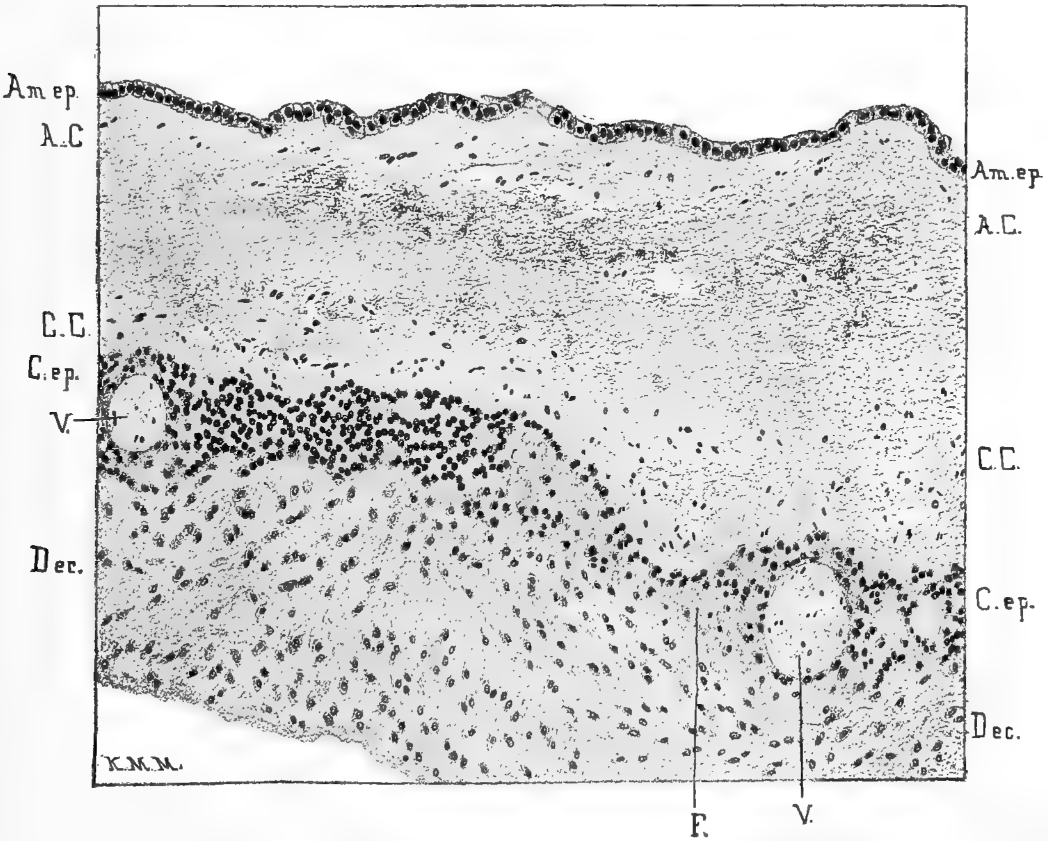

FIG. 1297.—Section through Fœtal Membranes and Decidua at Term, Outside of the Placental Site. Magnified 77 times. *Am.ep.*, Amniotic epithelium; *A.C.*, amniotic connective tissue; *C.C.*, chorionic connective tissue; *C.ep.*, chorionic epithelium; *V*, degenerated villi; *F.*, fibrin; *Dec.*, decidua.

In 1892–93, Kossmann and Merttens revolutionized for a time the teachings upon the subject, by stating that the Zellschicht represented the fœtal ectoderm, while the syncytium was derived from uterine epithelium, which then grew up over the villi. Their articles were very well illustrated and plausibly written, and distinctly demonstrated that the uterine epithelium could take on a syncytial character in places; but they were in error in supposing that it formed the outer layer of the chorionic covering. I have been able to confirm their observations to a certain extent, and have many specimens which positively demonstrate the transformation of tubal or uterine epithelium into syncytium. But the change is limited to isolated areas, and does not affect the entire epithelium, the greater part of which gradually becomes cuboidal and even flat, and eventually disappears. I therefore consider the formation of syncytium from the uterine epithelium as an accident, and perhaps a degenerative change which has nothing to do with the epithelial covering of the villi. Indeed, Gebhard and others have shown that the uterine epithelium may present a syncytial appearance without the existence of pregnancy, and have reported cases in which it was found in carcinoma of the uterus.

The theory of Kossmann and Merttens was presented so plausibly, and apparently so well confirmed, that it was rapidly accepted by most writers, among whom we may mention Marchand and Kollmann. It gradually lost ground, however, and at present the majority of the most recent writers upon the subject, among whom His may be mentioned, no longer believe in it, but state that both layers of the chorionic epithelium are ectodermal. The latter view has recently received marked confirmation from the work of Peters, who showed that the chorionic epithelium in the first week formed a distinct, many-layered capsule which he designated as trophoblast, the greater part of which consisted of distinct cells, though here and there small areas of syncytium could be observed. He therefore concluded that the fœtal ectoderm originally consisted of distinct cells, which assumed a distinctly syncytial appearance where they came in contact with the maternal blood. Peters' conclusions appear to be borne out by the facts, and at present most writers upon the subject subscribe to them.

For years this question has been a prolific source of discussion, and a voluminous literature has resulted from it. In 1890 Waldeyer carefully analyzed the literature, and was able to classify the theories concerning the origin of the chorionic epithelium into ten groups, to which several others have recently been added, all of which are carefully considered in Peters' monograph.

When the tips of the villi come in contact with the decidua serotina, the chorionic epithelium proliferates and invades the decidua to a greater or less extent. This was first recognized by Nitabuch, who pointed out that one could distinguish three layers in the decidua: a deep layer composed exclusively of decidual tissue, above which was a layer of fibrin, and above this another layer of cells which resembled the decidual cells very closely, but which were really fœtal in origin. She pointed out that the fibrinous line, which separated these two varieties of cells, was probably the result of degenerative changes in the chorionic epithelium, and accordingly represented the boundary line between the two tissues. Her views have been indorsed by most investigators, and at present it is generally believed that the decidua serotina is not made up entirely of maternal (decidual) tissue, but that its upper portion contains large numbers of fœtal cells.

On examining sections through the chorion outside the placental site, one finds at the end of pregnancy that it differs markedly from the chorion frondosum. Fig. 1297 shows a section through the fœtal membranes and the underlying decidua, and in it one can clearly distinguish the following layers: 1. The cuboidal epithelium of the amnion. 2. The amniotic connective tissue. 3. The chorionic connective tissue. 4. The chorionic epithelium. 5. Degenerated villi. 6. More or less canalized fibrin. 7. Typical decidua.

The chorionic epithelium is arranged in a number of layers, and consists of definite cells whose protoplasm stains lightly; the nuclei are vesicular in shape and stain quite darkly. Here and there in the chorionic epithelium one sees numerous large, pale, oval, or round, more or less structureless areas, which represent all that is left of the villi of the chorion læve. Occasionally they contain a few connective-tissue cells, but usually consist of a mass of transparent hyaline material. Beneath the epithelium and degenerated villi one finds a thicker or thinner layer of fibrinous material, which is evidently the result of the degeneration of chorionic epithelium. This tissue was first described by Langhans as canalized fibrin, and is characterized by the presence of numerous slits or canals of varying size. External to the canalized fibrin and chorionic epithelium one sees typical decidual tissue with its characteristic large, pale epithelioid cells.

Where the canalized fibrin is absent, the chorionic epithelium and the decidual cells come in intimate contact, the former extending down a slight distance into the latter. Where the two varieties of cells are commingled, it is almost impossible to differentiate between them; but when one compares distinct masses of chorionic epithelium with typical decidual tissue, it is readily seen that the former is composed of somewhat smaller cells with fairly darkly staining nuclei, while the latter is made up of larger, more irregularly shaped, paler cells, whose nuclei stain less intensely.

After the first few months degenerative changes are almost universally observed throughout the chorion, and usually appear as canalized fibrin. This tissue stains deeply with eosin and the usual dyes, and on close examination is seen to contain large numbers of spaces of varying shape, whence its name. It apparently results from coagulation necrosis of the chorionic epithelium, especially of the Zellschicht. And in many villi one sees a thicker or thinner layer of canalized fibrin, lying between the syncytial layer and the stroma. As the change becomes more marked, the syncytial layer is likewise converted into canalized fibrin, which eventually may even invade the stroma. Large quantities of this tissue are always present on the fœtal surface of the chorionic membrane, especially where it takes part in the formation of the placenta, and plays an important part in the formation of placental infarcts.

I have lately shown, in an article upon infarcts of the placenta, that the formation of canalized fibrin and infarcts is usually associated with more or less endarteritis of the villous vessels, and is to be regarded as a sign of senility of the placenta. It occurs so frequently that I believe it should be described as one of the normal constituents of the chorion. Similar changes are observed in the chorion læve, and it is probable that the degeneration of its villi is brought about in an identical manner.

In the early weeks of pregnancy, only a small portion of the cavity of the chorionic membrane is occupied by the embryo and the amnion (see Fig. 1292). This rapidly changes, however, and in a short time the amnion increases so rapidly in size as to line the entire interior of the chorion, so that the connective-tissue layers of both membranes lie in close contact. They do not appear to become organically united, as they can be readily separated in the full-term placenta after birth.

J. Whitridge Williams.

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CHORION. (PATHOLOGICAL.)—The pathology of the chorion remains at the present day largely an unknown field. Owing to the change of view regarding many of the conditions of the membrane formerly considered as pathological, but which are now looked upon as being only an expression of the senile decay of the organ, the known pathological conditions of the placenta have been brought within very narrow limits. It must be emphasized in this connection that the placenta is a temporary structure, and at time of delivery represents a senile, worn-out organ whose tissues are in an advanced stage of senile or physiological degeneration. These degenerative changes have in the past been looked upon as pathological and their true significance misunderstood. Having been interpreted as evidences of disease, serious misconceptions have crept into pathology regarding these purely physiological changes, and as a result the study of placental pathology has been greatly retarded. The majority of the conditions of the chorion described in the text-books as pathological, such as calcification, fatty change, sclerosis of the chorionic vessels, infarction, etc., are no more pathological than are the atrophy and sclerosis of old age, and should be regarded as possessing a similar significance. On the other hand, the peculiar pathology of the placenta—the causes of abortion, death of the fœtus, the part which the placenta plays in the transmission of disease, etc.—remains at the present time an unexplored field.

CIRCULATORY CHANGES.—It is impossible with our present knowledge to say to what extent the disturbances of the chorionic circulation are pathological. General hyperæmia and anæmia of the chorionic vessels are essentially dependent upon similar conditions in the fœtal circulation, but the conditions of pressure to which the placenta is subjected during delivery make it impossible for us to judge accurately of the former blood content of the organ. Though the placental end of the umbilical cord is usually ligatured, and the blood in this way retained in the chorionic vessels, the pressure of the uterine contractions during delivery will have materially altered the amount of blood in these vessels, even to such an extent that a previously existing hyperæmia may have been made to disappear entirely. On the other hand, if the placental end of the cord is not ligatured the chorionic vessels may be rendered anæmic through hemorrhage from the severed umbilical vessels. A general hyperæmia of the chorion may be caused by disturbances of circulation in the body of the fœtus, stenosis of the umbilical vein through thickening of its wall, twisting of the cord, etc. General anæmia of the chorion may be due to general anæmia of the fœtus, stenosis of the umbilical artery, twisting, knotting of the cord, etc. Local hyperæmia of the chorionic villi may be caused by some obstruction to the onward flow in the veins of the chorionic stems, or may be collateral dependent upon some neighboring anæmic area. Local anæmia of the vessels of the villi may be caused by pressure, obstruction of the larger arteries in the chorionic stems through thrombosis, sclerosis of the vessel walls, etc. As a result of thrombosis of the maternal sinuses a portion of the intervillous spaces may be deprived of maternal blood. The empty spaces collapse, the villi are pressed closely together, and as a result of the intraplacental pressure the vessels of the tightly packed villi become emptied of blood, giving rise to pale pinkish areas which have been regarded as infarcts. Necrosis of the villi (infarction) results from any severe degree of anæmia. In the case of twins arising from one ovum marked disturbances in the chorionic circulation may arise from the abnormal relations of the umbilical vessels. If one-sided hydramnion is also present the disturbance of the umbilical circulation may be very severe.

In general hyperæmia of the placenta the organ is deep red, swollen, bleeds freely when cut, and is of softer consistence than normal. Local areas of hyperæmia are deep red to black in color, and are frequently mistaken for hemorrhage. In general anæmia the placenta is pale, smaller than normal, and of firmer consistence. Localized anæmias appear as pale, pinkish, or white areas.

Hemorrhage.—Though hemorrhage from the maternal portion of the placenta is one of the most important pathological conditions of the organ, the escape of blood from the chorionic vessels is of very rare occurrence. Hemorrhage of the fœtal placenta has been very frequently described in the literature, but as the majority of these descriptions have been based upon the gross appearances alone, they cannot be accepted as conclusive. The term "placental apoplexy" has been applied to the circumscribed collections of fibrin and red blood cells so frequently found in the chorion, which from their occurrence in almost every ripe placenta can hardly possess a pathological significance. To the naked eye these appear as larger or smaller areas, deep red or black in color, of a firm consistence, and on section usually slightly elevated above the cut surface of the organ. They are found in greatest number near the maternal surface, but are also of frequent occurrence in the central portion of the organ, and at times extend entirely through it. On microscopical examination they consist of blood clots lying in the intervillous spaces. The blood may be freshly coagulated, or large masses of laminated or hyaline fibrin enclosing degenerating red blood cells may be found in the spaces between the villi. The clot may be so large as to compress the neighboring villi or to separate the chorion either partly or entirely from the maternal portion of the placenta. The blood in these cases of so-called "placental apoplexy" is of maternal origin, and since the blood is in the intervillous spaces which are themselves blood-vessels, it is not proper to consider this condition under the head of apoplexy or hemorrhage.

Numerous theories have been advanced to explain this condition, but none have proved satisfactory. Bustamente held that it is probably due to the occurrence of hemorrhage into a beginning infarct formation, the extravasation occurring into spaces bounded by necrosing villi instead of into the normal intervillous spaces. It is, however, more probable that the process is essentially a thrombosis beginning in the maternal vessels, and spreading thence into the intervillous spaces, involving a smaller or larger portion of the placenta. The majority of the cases described in the literature as hæmatoma of the placenta are, from their descriptions, evidently cases of infarction. Organization and encapsulation, calcification, liquefaction with cyst formation have been reported to occur as sequelæ of placental hæmatomata; but these were probably cases of infarction. The causes ascribed are varied: trauma, congestion, albuminuria, slow thrombosis of the maternal sinuses, excessive heart's action, etc. As a result of large hæmatomata the number of villi destroyed may be so great as to cause asphyxiation of the fœtus. True hemorrhage from the maternal sinuses does occur, and large extravasations may burrow downward through the decidua and escape from the uterus. Since in these cases the hemorrhage is of maternal blood, serious symptoms may be produced in the mother. Decidual hemorrhage plays also an important rôle in the production of abortion.

Rupture of the umbilical vessels or of the larger branches of the chorionic stems may lead to the production of true chorionic hæmatomata between the amnion and chorion. Death of the fœtus and abortion result if the hemorrhage is at all large. In some instances the hæmatoma may contain all of the blood of the fœtal body, the fœtus having bled to death into its own structures. Small hemorrhages from the capillaries of the villi into the chorionic stroma are occasionally seen. They are most probably dependent upon the changes in the walls of the chorionic vessels, or in many cases may be due to uterine contractions.

Œdema.—Œdema of the entire placenta occurs in retention of the dead fœtus and in connection with general anasarca of the fœtus caused by cardiac or renal disease, obstructions to fœtal circulation, fœtal leukæmia, etc. The placenta is swollen, boggy, and lighter in color, and tears very easily. The infiltration may be so great that fluid exudes when the organ is cut. The connective tissue of the villi is separated by the fluid, and the syncytial cells may contain large vacuoles. Hydramnion is usually associated with placental œdema.

Thrombosis.—While thrombosis is of very frequent occurrence in the intervillous spaces, it occurs much less frequently in the chorionic vessels. In both places it is in the majority of cases to be considered as a physiological process, a part of the means by which the placenta is freed from the uterus. Thrombosis of the chorionic vessels is one of the causes of placental infarction. It is directly dependent upon the senile changes in the walls of the chorionic vessels, which are of the nature of an obliterating endarteritis. If the thrombus is formed some time before the completion of term, it may become organized or undergo calcification. Early or excessive thrombosis must be regarded as pathological, but the conditions leading to this are not yet clear. Syphilis, maternal cachexias due to nephritis and other conditions, appear to be associated with more extensive thrombosis than is found in the chorion of normal placentas. It is probable that any thrombosis of the chorionic circulation before the beginning of the seventh month of gestation must be regarded as pathological. In the case of the physiological thrombosis occurring after this time the obliteration of the affected vessels is, in the first place, due almost entirely to the proliferating endarteritis, the obstruction being completed by the thrombosis. Following the obliteration of the main chorionic branch, there is a progressive thrombosis of the smaller arterioles, capillaries, and veins belonging to it. As a result of the shutting-off of the blood supply to the villi there follow marked degenerative changes in the structures of the villi which will be described under the head of infarction.

Infarction.—The so-called anæmic or white infarct of the placenta is one of the oldest described conditions of this organ. In the beginning mistaken for inflammation of the chorion, the history of the placental infarct and that of placentitis are for the greater part identical. Guillemeau in 1648, Mauriceau, Portal, and Morgagni a little later, were the first to note the occurrence of placental infarcts, but interpreted them as being inflammatory in nature. Later the same appearances of the placenta were accorded a great variety of interpretations, such as: atrophy, hepatization, phthisis, apoplexy, hæmatoma, fatty degeneration, hyaline, amyloid, gumma, etc. In recent years the minute changes underlying the gross appearances have been more clearly understood, and the present tendency is to consider them in the light of an anæmic necrosis dependent upon senile changes and having a physiological significance.

To the naked eye the infarcts of the placenta appear as yellowish-white or red areas, more or less sharply outlined, firm in consistence, and lacking the usual spongy appearance of placental tissue. They vary greatly in their location and size. They may be very large, involving several cotyledons or even half or two-thirds of the placenta. Usually they are of small size, varying from areas just visible to the naked eye to wedge-shaped or irregular areas several centimetres in diameter. They occur most frequently just beneath the fœtal and maternal surfaces of the organ, but may extend entirely through it. Not infrequently they form broad or narrow bands lying upon the surface of the chorion just beneath the amnion. These bands are usually but a few millimetres in thickness. They may occasionally run around the margin of the placenta (placenta marginata), or they may form a zone around the centre of the organ some distance from its periphery (margo placentæ), being separated from its edge by apparently normal tissue. In other cases red or yellowish areas are scattered through the substance of the organ and are discovered only when the placenta is cut. The red infarcts may vary in color from a pale pink to black. They occur most often upon the maternal side, but may extend completely through the organ. To these red areas the term "placental apoplexy" has been usually applied.

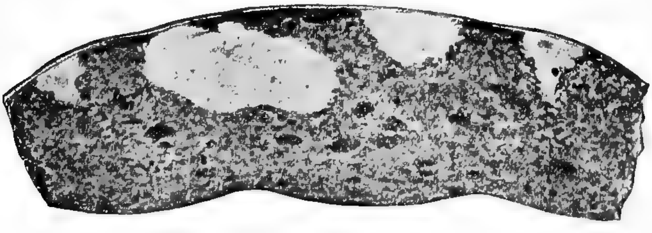

FIG. 1298.—Placental Infarction. Natural size. (After Kaufmann.)

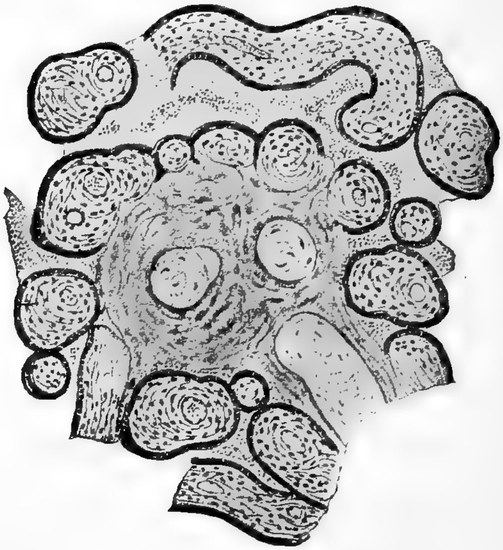

FIG. 1299.—Small Infarct of Chorion. Several necrosed villi surrounded by fibrin. The necrosed villi have lost their syncytial covering. (After Kaufmann.)

The red infarct may be elevated above the surface of the placenta, and in some cases the organ may be studded with small dark-red nodules (placenta truffé). The yellow or white infarct is more often depressed, and when of large extent may cause furrow-like depressions over the placental surface. On section the light-colored infarcts have a more or less fibrillated or laminated structure, but frequently appear cheesy. The red ones have a more granular surface. Calcification occurs with great frequency in the infarcts of all colors.

Microscopically the infarct consists of chorionic villi more or less necrosed and compressed together, surrounded by fibrin, red blood cells, and necrosing decidual septa. The nuclei of the connective-tissue cells of the villi have either entirely lost their chromatin or are disintegrating, the villous elements becoming fused into a hyaline mass, taking a uniform pink stain with eosin. The syncytial cells are partially desquamated and fused into black-staining masses of chromatin, while the cells of the decidual septa between the villi are swollen, vacuolated, and exhibit various stages of necrosis. Fibrin is deposited upon and around the villi, and is made up of closely packed fibrillæ so that it appears almost hyaline. It stains with Weigert's fibrin stain in the same manner as does fibrin found elsewhere.

In other cases the infarct consists only of large masses of laminated fibrin in which no traces of villi can be found. Others contain shadows of necrosed villi, and between the infarcts containing no villi and those exhibiting necrosing ones every stage of transition may be found. Those consisting only of fibrin are probably to be regarded as older infarcts. In the fibrin masses degenerating red cells are found in large numbers, and not infrequently there is a well-marked infiltration of leucocytes into the fibrin. Lime salts may be deposited in the dead villi, the syncytial cells, or the necrosing decidual cells, or in the fibrin. Fatty degeneration of the necrosing villi is rare. In large infarcts a liquefaction or simple softening of the central portion may take place, resulting in the formation of a pus-like fluid, which may lead to an incorrect diagnosis of abscess of the placenta. As a rule, the villi immediately bordering upon the infarct show no change, but occasionally there may be a sequestration of the infarct, or formation of a connective-tissue capsule about it. Rarely a leucocyte infiltration is seen about the infarct.

In small infarcts the changes are not so marked, and the villi (one or several in number) may be but slightly changed, and surrounded by a narrow ring of hyaline fibrin. The syncytium usually shows some evidence of necrosis or desquamation, but the stroma of the villus may remain unchanged. The structure of the surface and central infarcts is essentially the same. The large pink infarcts are similar to the white ones except in the fact that the red blood cells are preserved. The red infarcts may present a microscopical appearance exactly similar to that of the white ones. In other cases the fibrin composing them contains many red cells. Non-fibrinous infarcts may also occur, to the naked eye resembling the white fibrinous ones, but microscopically consisting of necrosed villi crowded closely together without intervening fibrin. Eden believes that these are caused by the shutting off of the blood in the decidual sinuses whereby the supply to the intervillous spaces is obstructed. These, being no longer filled with blood, collapse, and the villi being thus closely crowded together, become anæmic and undergo necrosis.

The larger blood-vessels of the chorionic stem to which the infarcted villi belong, show, as a rule, a well-marked obliterating endarteritis and periarteritis associated with thrombosis, and it is probable that the infarction is due to these conditions.

While there is among recent writers a universal agreement as to the minute structure of placental infarcts, there is still some diversity of opinion as to their etiology and pathological significance. Two schools exist. One holds that infarcts are the result of degenerative changes occurring in the decidua and extending thence to the neighboring villi, the intervillous fibrin masses representing degenerated decidua. Proliferation of the decidua may even first take place. The changes in the chorionic vessels are regarded as purely secondary. The other school holds that the vascular changes in the chorion are primary, and that as a result of these, necrosis of the villi occurs followed by the deposition of fibrin upon and about the dead villi. This school also regards the infarction process as physiological and not the result of disease changes. This latter view must be accepted in view of the recent observations concerning the occurrence of infarcts in the ripe placenta.

Delore, in 1899, found in the examination of several thousand cases that infarcts occurred in one hundred per cent. Williams, in 1900, states that he has found infarction in greater or less extent in every full-term placenta examined. The writer in an examination of one hundred successive placentas found them in every case. Many of the older writers at widely separated periods of time expressed the belief that infarcts (described under various heads) were found in the majority of all placentas. Eden was one of the first of the more recent writers to emphasize the constant occurrence of placental infarcts as being of a physiological nature and not as evidence of disease. His views have recently been confirmed by Williams and others.

According to Ackermann, Eden, and Williams, the chief factor in the production of placental infarction is to be found in the changes occurring in the chorionic vessels. These are of the nature of an obliterative endarteritis and periarteritis, and are usually most marked in the vessels of the chorionic stems and in the larger arterioles of the villi. The degree to which this change occurs varies greatly; in many cases the lumen of the vessel may be almost or entirely obliterated, while in others there is but a slight thickening of the intima. The endarteritis is similar to that found in other regions of the body; there is a proliferation of the subendothelial connective tissue with resulting narrowing of the lumen, the newly formed tissue becomes hyaline and gradually loses its nuclei. There may or may not be an increased number of wandering cells in the vessel wall. Calcification occurs much less frequently than in sclerotic vessels in other parts of the body.

These sclerotic changes occur in all healthy placentas; their etiology is unknown, but inasmuch as they form a part of the life history of the organ, the causes leading to their production must be sought for in the operation of the general laws of histogenetic development and decay. Under ordinary conditions, to be regarded as an expression of senile degeneration, these vascular changes can come to have a pathological significance when they appear at an earlier period than normal. In such case they are to be taken as an indication of premature senility.

As a result of these vascular changes disturbed nutrition of the tissues of the villi occurs. This is shown in the first place by a necrosis of the cells lying just beneath the syncytium. This leads gradually to a desquamation of the syncytial layer. Changes in the chromatin of the syncytial cells take place but slowly, leading to the inference that these cells may derive some nourishment from the maternal blood. They do not begin to degenerate until the tissue beneath has reached a certain degree of necrosis. As the process advances the connective tissue of the villus undergoes necrosis, becoming changed into a hyaline mass which stains deep red with eosin. The necrosis of the surface of the villi is of the nature of a coagulation necrosis, fibrin is deposited upon the dead cells. As the process advances larger pieces of syncytium degenerate, and upon these dead cells there is deposited a thick layer of hyaline fibrin which binds the dead villi together in a firm fibrinous mass. In the oldest portions of the infarct the villi gradually lose their contour, the central portion of the infarct becoming after a time an indistinguishable mass which may either liquefy or undergo calcification. The syncytial cells may be preserved for a long time in the meshes of the fibrin, appearing as deeply staining clumps of chromatin.

According to Williams, the death of the stroma of the villus is also of the nature of a coagulation necrosis by which the tissue of the villi becomes changed into canalized fibrin. The writer, in the study of a large number of infarcts, has never seen anything warranting the belief that fibrin may be formed from necrosing villous stroma. While the dead villi stain similarly to fibrin with many stains, the proper management of Weigert's fibrin stain will always differentiate between the dead villi and the true fibrin derived from the blood elements.

While the great majority of all placental infarcts are undoubtedly due to the vascular changes in the chorion, it seems possible that in certain cases the infarction is the result of changes beginning in the so-called decidual septa which extend into the chorion. Eberhardt, Williams, and others believe that these septa are of ectodermal origin and not maternal. If this is the case the primary factors in the production of infarction are to be sought always in fœtal structures. On the other hand, Steffeck and others hold that infarction is always of maternal origin, the primary change taking place in the cells of the septa, the latter being extensions of the maternal decidua into the chorion. The necrosis of these cells leads to the formation of fibrin in the intervillous spaces which contracting compresses the villi and so leads to their necrosis.

The pink infarcts do not differ in their etiology from the white ones, but are most probably to be regarded as more recent infarcts, the blood between the necrosing villi having undergone but imperfect coagulation. The large dark-red infarcts commonly regarded as "placental apoplexy" are due to dilatation and thrombosis of the intervillous spaces, and are not hemorrhages. Their etiology and significance are not yet known, but it is probable that they are connected with the thrombosis of the maternal sinuses which gradually extends into the intervillous spaces involving a larger or a smaller portion of the placenta. The origin of the non-fibrinous infarcts is probably that suggested by Eden, as mentioned above.

As sequelæ to infarction there may result a gradual atrophy or absorption of the dead villi and fibrin, simple softening with formation of a pus-like material, calcification, or in rare cases organization may lead to the formation of a fibroma-like mass of connective tissue. Chorionic cysts may also be formed by the liquefaction of the central portion of an infarct.

The sclerotic changes in the chorionic vessels and the resulting infarctions must be considered as purely physiological processes in the great majority of all full-term placentas. Unfortunately, the significance of these conditions is at the present time but little understood, and consequently normal phenomena have been accorded the most varied pathological interpretations. Such mistakes are due entirely to a lack of familiarity with the changes found in normal placental tissue. In all healthy placentas infarcts are constantly found, and are present at all stages of gestation from the earliest period of chorionic development. A progressive atrophy and disappearance of the villi in the chorion læve occur from the very beginning of placental formation, and this is the normal way in which the extraplacental villi are disposed of in the earlier weeks of gestation. In the fœtal placenta itself from the very beginning there is on one hand a progressive formation of new villi and a progressive destruction on the other. This process is but the extension of that from the extraplacental chorion, and a definite progression can be traced between the infarctions of the extraplacental villi and those of the placental chorion. As Eden has pointed out, infarction is therefore "not the result of pathological factors but forms a part of the normal life history of the placenta, and its etiology is to be looked for in the operation of the natural forces of evolution and decay."

Yet many authors seek to give a pathological meaning to the infarcts found in the full-term placenta. Von Franqué holds that the vascular changes in the chorionic vessels are pathological and lead to placental œdema, excess of the amniotic fluid, etc. Cohn, Wiedow, Martin, Pinard, and others believe that there is some definite relation between maternal albuminuria and placental infarction, and that the latter process leads to marked changes in the condition of the fœtus even to the extent of death and abortion. A relation has also been claimed to exist between infarction and eclampsia. Zilles, Prinzing, Orth, and others believe that there is a causal relation between syphilis and infarction. Favre, Martin, and Delore hold that infarcts are caused by the presence of bacteria in the blood of the intervillous spaces, that these cause degeneration and necrosis of the syncytial cells which in turn lead to infarction. Williams examined twenty placentas bacteriologically and found the infarcts to be sterile. The latter writer holds that moderate infarction is not pathological and exerts no harmful influence upon either mother or fœtus. Marked infarction he believes to be associated usually with maternal albuminuria, and often results in the death or imperfect development of the fœtus. He is unable to account for the relationship between the two conditions.

According to the results of the writer's study of a hundred full-term placentas, large infarctions may be found in cases in which there was no albuminuria and in which both mother and child were apparently normal. Such infarctions are, however, of greater frequency in the placentas from mothers suffering from cachectic conditions of all kinds, tuberculosis, syphilis, nephritis, anæmia, severe endometritis, etc.; and it is probable that in such conditions the infarct acquires a pathological rôle and may affect the development of the fœtus. Especially is this likely to be the case when large infarctions occur in the early months of gestation. The occurrence of large infarcts before the seventh month seems to be especially associated with syphilis. The significance of chorionic infarction may then be summed up as follows:

1. Moderate infarction of the placenta after the seventh month is physiological.
2. Marked infarction of the ripe placenta may have apparently no pathological significance, but is usually associated with maternal cachexias and may affect fœtal development.
3. Marked infarction of the placenta in the earlier stages of gestation is especially associated with syphilis, tuberculosis, and nephritis of the mother, and may result in abortion.

Atrophy.—There is in the fœtal placenta from the very beginning of its development a progressive atrophy of the chorionic villi on the one hand, and a new formation on the other. The superfluous villi of the chorion læve undergo a simple atrophy, and the process extends from them to the placental chorion. At term the villi are, as a rule, of much smaller size than in the early months, and this decrease in size is to be looked upon as being of the nature of a histogenetic or senile atrophy. The myxomatous tissue of the young villi takes on with age somewhat of the character of mature connective tissue, and while many of the villi never lose entirely their embryonic character, their interstitial tissue becomes firmer and more compact, and contracting causes a marked decrease in size. The small vessels of the villi are, however, not affected by this contraction; on the contrary, they become relatively much larger. If these atrophic changes occur to any great extent before the seventh month they must be regarded as pathological. Premature atrophy may be due to syphilis, or to marked cachexias due to other causes. The direct cause of both physiological and pathological atrophy lies in the sclerotic changes in the larger chorionic vessels. Slow obliteration of these vessels leads to simple atrophy of the villi, while a more rapid shutting-off of the circulation leads to infarction. The first structure of the villus to show signs of atrophy is the deep layer of the chorionic epithelium. In the young placenta the epithelial covering of the villi consists of two layers: a superficial layer of nucleated plasmodium, and a deep one of well-defined nucleated cells. After the third month this deeper layer undergoes atrophy so that in the ripe placenta it has almost entirely disappeared, being represented only by scattered nuclei beneath the plasmodial layer. The plasmodial layer undergoes a similar atrophy in the last months of gestation. In the ripe placenta many of the villi show in places complete atrophy of the plasmodium, so that underlying capillaries may be directly exposed to the maternal blood. The loss of vital energy in the syncytium is further shown in the last two months by the gradual cessation of bud and process formation whereby the development of new villi comes to a standstill. The changes in the stroma occur at the same time with those in the syncytium. Fibrin is never deposited upon villi showing simple atrophy alone, but only upon those showing necrosis or degeneration.

Necrosis.—Necrosis of the villi occurs in infarction as described above. It is usually of the nature of a simple necrosis, but many writers regard it as being a form of coagulation necrosis. The stroma just beneath the syncytium is the first part affected; its nuclei become swollen, irregular in shape, and there is a gradual loss of chromatin. The syncytium then necroses and fibrin is deposited upon the dead surface of the villus. The formation of fibrin from the degenerating structures of the villus, as claimed by Williams and others, is not yet an established fact. Necrosis of the villi occurs also in retained placenta after the birth of the fœtus, after abortion, or in connection with a retained dead fœtus. Infection with putrefactive organisms may occur, and moist gangrene result. In a number of cases gaseous emphysema of the necrosing placenta has been observed, and the Bacillus aërogenes capsulatus was found to be present both in the fœtus and in the placenta. The sequelæ of necrosis of the villi are the same as those given under infarction.

Cloudy Swelling.—Preceding the necrosis in infarction there is a stage of degeneration in the syncytial and subsyncytial cells which is analogous to the cloudy swelling of parenchymatous organs. The cells become swollen, their nuclei larger, the cell outline irregular, and there is a gradual disintegration of the chromatin. Such changes are very commonly found throughout the entire placenta in retention of the organ after abortion, delivery, or in connection with death of the fœtus.

Hydropic Degeneration.—This occurs in œdematous placentas, in necrotic placentas retained after abortion or delivery, in gangrene, placental inflammation, hydatid moles, and in the chorionic villi of ectopic gestation. The villi showing this degeneration contain large vacuoles throughout their stroma. Vacuoles may be found also in the syncytium and in the cells of Langhans' layer.

Fatty Degeneration.—A very slight degree of fatty degeneration of the villous stroma must be looked upon as a normal condition in the last months of pregnancy. Extensive fatty degeneration of the placenta was first described by Barnes, but there can be no doubt that the changes which he saw were those of infarction. As the result of his error the literature from 1851 to 1890, both in England and in this country, contains numerous reports of fatty changes of the placenta based upon the gross appearances, and the descriptions in all of these cases correspond to the gross changes seen in infarction. Marked fatty degeneration of the villi is very rare, and is confined almost entirely to the villi in ectopic gestation after the death of the fœtus, but the degeneration occurs to a lesser degree in placentitis, infarction, retained placenta, etc.

Myxomatous Degeneration.—The stroma of the chorionic villi and also of the chorionic stems is during the early months of pregnancy of the nature of myxomatous tissue. In the later months it takes on more of the nature of mature connective tissue, especially in the stems, where it comes to resemble fully developed fibrous connective tissue. Many of the villi, however, never entirely lose their embryonic type. In some cases the entire chorion may retain the character of myxomatous tissue, in other cases there is a myxomatous degeneration of the mature connective tissue of the stems and larger villi. This degeneration occurs in the placentas of cachectic individuals and in retained placentas after delivery at full term. Associated with a persistence of embryonic type or with a myxomatous degeneration there may be a hyperplasia of the chorion which gives rise to the condition known as vesicular mole, hydatid mole, etc. (see below).

Hyaline.—Within certain limits a hyaline change in the walls of the blood-vessels of the chorionic stems is physiological in the ripe placenta. Early or excessive change of this nature must be regarded as pathological. This occurs in the pre-senile condition caused by syphilis and other cachexias.

Amyloid.—The presence of amyloid in the chorion has been reported a number of times, but it is highly probable that the changes seen were those of infarction, and that hyaline fibrin was mistaken for amyloid.

Calcification.—The deposit of lime salts in the chorion is also within certain limits to be regarded as a senile process. Small areas of calcification are very common in the ripe placenta, occurring practically in every one, and are entirely without pathological significance. The deposits may be scattered throughout the chorion, as many as five hundred concretions having been found in one placenta, or the entire surface of the chorion beneath the amnion may be covered with a calcareous deposit. In the latter case the deposit is found in the layer of fibrin lying between the amnion and the chorion. In the scattered deposits the calcification occurs chiefly in the intervillous fibrin masses, but may be found in any portion of the chorion, in the syncytial layer, the connective tissue of the villi, or in the walls of the blood-vessels of the chorionic stems. The deposits occur most frequently in or about areas of infarction. They are usually of small size. To the naked eye the presence of calcareous masses in the placenta is shown by whitish areas having a firm consistence, a gritty feel, and giving a grating sound when struck with a knife. Microscopically the deposit consists of irregular masses of calcium carbonate, phosphate, or magnesium phosphate, giving the characteristic staining reaction with hæmatoxylin.

Just when calcification takes on a pathological significance it is at present impossible to say. Extensive deposits may occur when both mother and child are apparently in perfect health. On the other hand, it has been claimed that calcification to an extensive degree is associated with syphilis and death of the fœtus, but no constant association can be shown to exist. In placentas before the seventh month calcification has the same significance that infarction or sclerosis has at this period; it is to be taken as an evidence of premature senility, and dependent upon nutritional changes resulting from syphilis, tuberculosis, or other cachectic conditions. In both syphilis and nephritis a fatty degeneration of the terminal villi usually precedes the calcification. Early infarction dependent upon early obliteration of the chorionic vessels is almost always followed by calcification if the nutritional disturbances are not so great as to produce abortion. Syphilis is the most commonly associated condition, and may therefore be regarded as an etiological factor. Since calcification most frequently follows infarction, the greater the number of infarcts the more extensive the calcification. It may therefore be taken to a certain extent as an expression of the degree of senile change, but it must be remembered that in many cases infarction is not followed by any deposit of lime salts. In the retained placenta, either after delivery or after abortion, calcification is of very frequent occurrence. It is also very frequently found in the chorion in ectopic gestation. Both membranes and fœtus may be entirely calcified (lithopædion). On the other hand, sclerosis of the chorionic vessels is but rarely followed by calcification of the vessel wall.

Pigmentation.—Pigmentation of the chorion is very rare. Hæmatoidin and hæmosiderin may be found in old infarcts, but, as a rule, these pigments are not formed in the placenta from the disintegration of the red cells. They are of more frequent occurrence in retained placentas. In malaria of the mother the blood in the intervillous spaces contains both the malarial organism and its pigment. The latter may be deposited upon the surface of the syncytium, but does not pass through this layer. Retained placentas in cases of severe icterus of the mother become stained with bile pigment, the pigmentation being confined to the syncytial layer except in those portions of the villi denuded of syncytium where the stroma of the villus is also bile stained.

Fibrinoid Degeneration.—Much has been written upon the origin of placental fibrin, and the subject cannot be said to be definitely settled. Ackermann holds that it arises from the decidual cells and from the plasmodial and cellular layer of the villi, and not from the maternal blood. Minot also affirms that it arises from a degeneration of the chorionic epithelium. Williams believes likewise that the syncytium undergoes coagulation necrosis and is converted into canalized fibrin. Eden considers it to be largely a product of the maternal blood. The process has been styled hyaline, fibrous, fibrinous, hyaline-fibrinous, and fibrinoid degeneration of the placenta by the various authors who regard it as being of the nature of a degeneration, but who have given but little proof of their assertions. The writer, after a careful study of many placental infarcts, has been unable to convince himself that the placental fibrin has any other origin than that of the maternal blood. While with ordinary stains the intervillous fibrin has a hyaline, homogeneous appearance, indistinguishable from the necrosed syncytium and decidua, a differentiation can always be made with Weigert's fibrin stain. When stained by this method, the fibrin always shows a reticulated structure, in the meshes of which lie necrotic cells of the syncytium and decidua.

Progressive Changes.—During the first seven months of gestation there is a constant new formation of chorionic villi. Proliferation of the nuclei of the syncytium takes place, leading to the formation of a plasmodial bud or offshoot, which becomes vascularized from the villous capillaries, and a stroma is formed for the young villus from the proliferation of the stroma cells of the parent villus. During the last two months of pregnancy the formation of the plasmodial buds continues, but very few become vascularized. The number of buds is, moreover, not so great as in the early months. In sections of the placenta these buds appear as large plasmodial giant cells when cut transversely. They are frequently very numerous around infarcts, suggesting a compensatory regeneration. Rarely the placenta at full term is increased in size, and shows active proliferation of the villi as in the early months. With this hyperplasia there may be associated a myxomatous or hydropic degeneration of the stroma of the villi, giving rise to the condition known as vesicular or hydatid mole. A similar process takes place after abortion or delivery in case the placenta is retained, but is much more frequent and extensive the earlier the death of the fœtus occurs. The retained placenta, after abortion, may live with not only a lessened, but frequently an increased vitality many months after the death of the fœtus, and this may lead to a hyperplasia of the villi resembling in character that of a new growth. These hyperplastic growths of the chorion may be found in all stages from the slightly increased activity in the formation of syncytial buds to the development of atypical buds infiltrating the uterus wall and producing metastases in other organs. Various names have been given to these growths, and their terminology is at present confused. It is difficult to draw any close distinction between the simple hyperplasias on the one hand and the new growths on the other. For reasons of convenience they will be described under the head of tumors of the chorion.

Placentitis (*Chorionitis*).—Though the term placentitis occurs frequently in the literature, the actual anatomical observations of inflammatory conditions of the fœtal placenta are so rare and the interpretation of these so varied and conflicting that the condition cannot be said to have a definite status in pathology. Throughout the older literature there are references to placental inflammation as an occurrence possible but rare. It is first definitely mentioned by Guillemeau in his "Oeuvres de Chirurgie," 1648. Mauriceau, Portal, and Morgagni gave clinical descriptions of "placentitis" unsupported by anatomical observations. Cruveilhier, Murat, Brachet, Stein, d'Outrepont, Wilde, Simpson, and Rokitansky made many observations by which they declared the existence of placentitis to be conclusively proved, that it was both acute and chronic in its course, and in common with other inflammations possessed three stages. The conclusions of these observers were based wholly upon the gross appearance of the organ and upon a theoretical application of the changes seen in croupous pneumonia. The modern reader can have no doubt that they saw and described the placental infarct. In 1849 Scanzoni gave a more exact description of infarction, showing that the yellowish areas consisted of fibrin. He, however, interpreted the condition as inflammatory in nature and designated it as "phthisis placentæ." He was supported in these views by Mattei and Geoffroy.

But doubt as to the correctness of these views soon arose. Verdier and Bustamente explained the phenomena as due to retrograde metamorphoses of blood clots. Robin especially opposed Scanzoni's views, and gave the process a wholly different interpretation. According to his observations there did not exist a true inflammation of the placenta, at all events no one had yet seen it. What had been taken for placentitis he affirmed was nothing more than a "fibrous" degeneration of the chorionic villi arising from the obliteration of the chorionic vessels. Doubt as to the existence of placentitis then took a more definite form. Millet, in 1861, said: "Nothing is less precise than the symptomatology of this affection, nothing is less exact than its pathologic anatomy, in a word, nothing is less proved than this inflammation itself." In 1862 Maier and Hegar studied very carefully the phenomenon formerly described as placentitis. After a minute description of the well-known appearances and structure of the white infarct, they decided that the partial necrosis of the villi near the fibrin masses was the expression of an interstitial placentitis similar in its nature to hepatic cirrhosis. Maier noted also the periarteritis of the chorionic vessels, and considered the two conditions to be closely related and to lead to the same result, atrophy and degeneration of the villi.

In 1869 Charpentier doubted very much the existence of a true inflammatory condition of the placenta. The pathological anatomy of the organ became more and more unsettled, and the disposition to reject placentitis altogether rapidly increased. Many opinions were given asserting the impossibility of a placental inflammation in the Cohnheim sense of the process, since there "are no capillaries in the maternal placenta through which a migration might take place and no nerves to regulate the contractility of the vessels throughout the organ." The opinion of Robin came to be most generally accepted: "What has been taken for inflammation of the placenta is nothing else than a condition of transformation of blood clots at different stages. What has been regarded as pus is only fibrin in the course of disorganization, and in those cases where true pus has been found the pus did not come from the placenta but from an inflammation of the tissue of the uterine walls and an accidental deposition in the tissue of the placenta."

In 1884 Ackermann declared all previously entertained views to be incorrect, and explained all of the observed phenomena on the theory of an anæmic infarct of the placenta. His views were accepted by the majority of pathologists in so far as the question of the existence of placentitis is concerned. An immense quantity of literature concerning placental infarction now sprang into existence, and from 1884 to the present time the question of placental inflammation has been practically relegated to a far background. In summing up the gleanings from the literature we find that the older writers believed in the existence of a placentitis which they constructed from clinical phenomena, inaccurate gross observations, and still more inaccurate microscopical examinations and weakly grounded reasonings from analogy. As the knowledge of pathological histology developed the status of placentitis became more and more unsettled, and the changes which the older observers looked upon as inflammatory were shown to be of the nature of infarction, and finally, in our own day, to be considered as only the expression of senile decay of the organ. The literary history of placentitis is the history of the placental infarct, and inflammation of the placenta as a definite pathological entity has almost disappeared from the later literature, and its existence is affirmed only by scattered and unsatisfactory observations.

Small foci of leucocytes are not infrequently seen in the ripe placenta, especially in the neighborhood of infarcted areas, but their significance is unknown. A true purulent inflammation of the maternal portion of the placenta is relatively common. It may be due to gonorrhœal infection, or to an extension of a neighboring purulent process to the endometrium and decidua. In the earlier months it may be due to infection resulting from attempted abortion. The cells of the decidua undergo a liquefaction necrosis, and there is a large leucocyte infiltration which may assume the proportions of abscess formation. The leucocyte infiltration extends along the decidua and into the decidual septa, but only in rare cases involves the chorion, the uppermost layer of the decidua apparently acting as a barrier to the extension of the process. The chorion is most likely to be involved when the decidual inflammation occurs in the early months. In such cases the syncytium becomes swollen and hyaline, gradually losing its nuclei, and taking a very deep stain with eosin, but does not give the fibrin stain with Weigert's method. The stroma of the affected villi is partly or wholly liquefied and replaced by leucocytes. Each villus may come to have the appearance of a small abscess surrounded by the syncytium, which remains intact long after the stroma of the villus is entirely destroyed. The formation of syncytial buds may take place even at this stage. Fibrin is formed in the intervillous spaces, but is not so homogeneous and hyaline in character as in the placental infarct. Leucocytes may or may not collect upon the surfaces of the affected villi, and in the early stages of chorionitis there

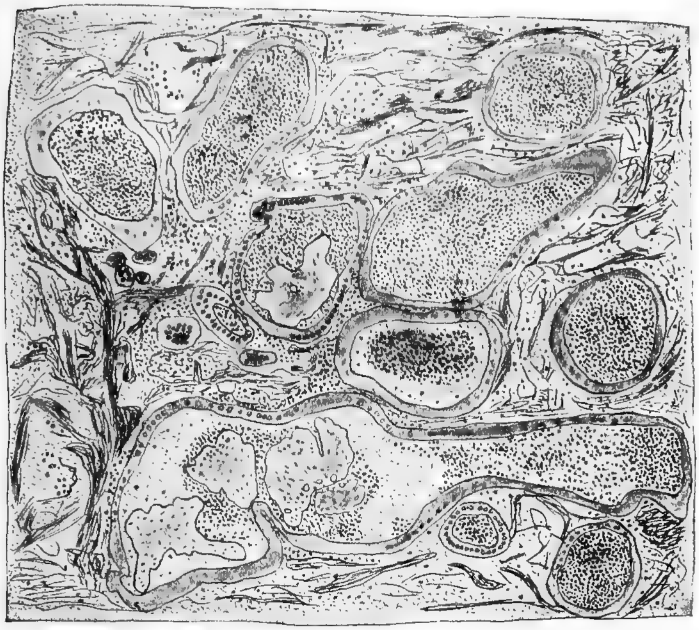

FIG. 1300.—Purulent Chorionitis. Placenta and fœtus removed one week after attempted abortion in the third month. Stroma of the villi almost wholly liquefied and replaced by pus. Syncytium swollen and hyaline, gradually losing its nuclei. A few well-preserved buds lying in the intervillous spaces which contain fibrin and an increased number of leucocytes. Camera lucida drawing. Leitz objective No. 3; eyepiece No. 2; reduced one-third.

may be no coagulation in the intervillous spaces, even when the changes in the syncytium and stroma of the villi are far advanced. The place of extension of the purulent process from the decidual septa to the chorion may usually be discovered. Ultimately the complete destruction of the affected portion gives rise to a well-defined abscess of the placenta. Death of the fœtus, general sepsis on the part of the mother, may result, or in rare cases the pus may burrow downward through the decidua, escaping from the uterus, and the gestation go to full term. Purulent inflammation of the decidua and chorion is of frequent occurrence in the retained placenta after abortion and delivery, and in the placenta of ectopic gestation.

Interstitial chorionitis, both acute and chronic, has been described. The acute forms occur only in the early months of gestation, and are practically always due to syphilis or tuberculosis, and will be described under those heads. The condition described as chronic interstitial placentitis is in reality only the fibroid change which takes place in the chorionic stroma as a result of the normal or premature obliteration of the chorionic vessels, and can hardly be considered as inflammatory in nature.

Periarteritis, Endarteritis.—The changes in the chorionic vessels were at a very early period regarded as inflammatory in nature. As before mentioned, the present view is to consider them in the mature placenta as being of the nature of senile changes. They acquire a pathological significance only when occurring prematurely or to an excessive degree. The process begins as a rule in the terminal and medium-sized arterioles, later in the larger arteries, while the veins and capillaries are not affected until the blood supply is almost shut off by the arterial changes. The first indication of the process is shown in a thickening of the adventitia. Very soon the intima is involved, the subendothelial cells proliferating irregularly, forming localized growths into the lumen, or a more regular narrowing of the lumen as a whole. When the lumen is almost entirely obliterated, there is usually a loss of the endothelium and the obturation of the vessel is completed by thrombosis. In the tissue about the affected vessels there may or may not be any increase in the number of wandering cells. These changes begin as early as the seventh month and progress until delivery. They are the direct cause of infarction.

Syphilis.—The changes in the chorion ascribed to syphilis are numerous and varied. Infarction, fatty change, calcification, sclerosis of vessels, fibroid degeneration, interstitial placentitis, etc., have all been regarded by various authors as being of syphilitic origin. As seen above, many of these conditions are physiological within certain limits, and in the present state of our knowledge it is impossible to say definitely as to when they acquire a pathological significance, and their relation to syphilis is still more obscure. Fränkel has observed in cases of early fœtal syphilis transmitted from the father a form of acute interstitial chorionitis in which there is a marked proliferation of the cells of the villous stroma. This loses its myxomatous character, its blood-vessels are obliterated, the villi become greatly thickened, and as a result the intervillous spaces are decreased in size. The newly formed stroma is of a fibroblastic character, rich in large spindle-shaped cells, having more or less vesicular nuclei. The change may affect the entire chorion, or scattered areas of the condition may be found throughout the organ. The former is most likely to occur when the infection occurs at conception, the latter in syphilis acquired in the first months. In the former case death of the fœtus and abortion invariably result, in the latter gestation may go on to full term with the birth of a child showing marked syphilitic manifestations. The fibroblastic character of the affected villi may be maintained until delivery or the stroma may gradually assume a hyaline character. Early and marked scle-

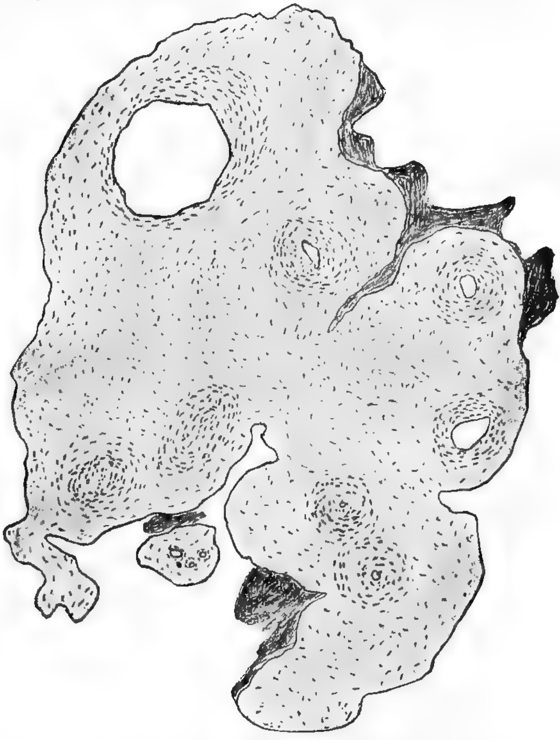

FIG. 1301.—Chorionic Stem from Ripe Placenta, Showing Normal Obliteration of Chorionic Arteries. Fibrin adhering to edge; Camera lucida drawing. Leitz No. 3 objective; eyepiece No. 2; reduced one-third.

rosis of the chorionic vessels accompanies the process, and, as a result of this, infarction occurs to an excessive degree. This form of interstitial placentitis does not, however, occur in all cases of early congenital syphilis, and fœtal syphilis may exist without any apparent changes in the placenta. Syphilis of the mother, acquired in the later months of gestation, may or may not affect the chorion. The general effect of maternal syphilis upon the chorion is the production of a premature senility as shown by early and extensive sclerosis and infarction. None of the chorionic conditions caused by syphilis has anything specific in its character. A similar interstitial chorionitis (localized and not diffuse) may be caused by the tubercle bacillus. Gummatous growths are not found in the chorion, though they have been described as occurring in the maternal portion of the placenta.

Tuberculosis.—Tuberculosis of the fœtal placenta has been repeatedly observed during the last decade (Schmorl, Kockel, Warthin, etc.). Typical caseating tubercles, with giant cells, and containing tubercle bacilli, have been found in the chorionic villi, and the writer has seen one case in which there were localized areas of interstitial chorionitis, with giant cells but without caseation, containing tubercle bacilli. The fœtus may be infected secondarily to the tuberculous condition in the chorion, while in other cases, as the one reported by Schmorl and Birch-Hirschfeld, tubercle bacilli may be found in the fœtus without the occurrence of changes in the chorion characteristic of tuberculosis. It is doubtful if the bacilli in the blood of the maternal sinuses pass through a perfectly normal syncytium, the tuberculous proliferation of the cells of the villous stroma being either secondary to a necrosis of the syncytium, upon which the bacilli have lodged, or the diseased villus had previously lost its plasmodial covering, whereby the bacilli were brought into direct contact with the stroma. Tuberculosis of the chorionic villi may also occur in ectopic gestation, as in a case reported by the writer in which the cyst wall, placenta, and fœtus, as well as both Fallopian tubes, were tuberculous.

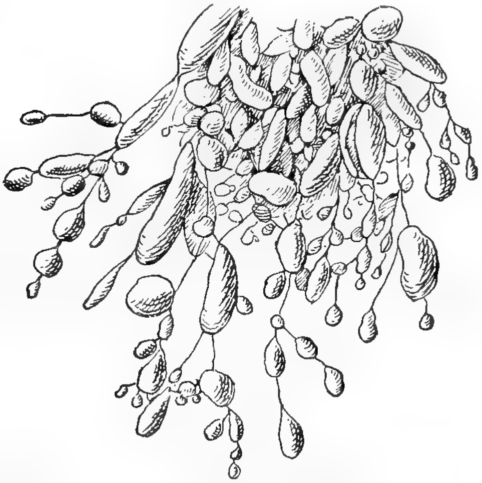

FIG. 1302.—Hydatid Mole. Myxomatous degeneration of chorion. (After Ziegler.)

Atelectasis of Chorion.—Küstner has observed in the lowest portion of normal placentas, and especially in placenta prævia marginalis, certain areas in the edge of the organ which were thinner, firmer, dryer, more homogeneous, and of a browner color than normal. Microscopically, no other pathological changes are found beyond such a close crowding of the villi that the intervillous spaces are obliterated. He has explained these changes as being the result of a continued pressure from overlying parts of the fœtus, and comparing the condition to atelectatic changes in the lungs he has designated the condition as chorionic atelectasis.

Tumors.—The most frequent and important of the new growths of the chorion are those resulting from increased activity in the syncytium. These form a large class of closely allied conditions, ranging from a simple hyperplasia of the villi to atypical growths of a malignant nature. Since all writers are not yet agreed upon the genesis of the syncytium, the terminology of these growths is unsettled and confused. They may, however, be divided into two large classes: the moles or benign syncytiomata, and the syncytioma malignum.

Moles.—A simple hyperplasia of the chorionic villi may occur at any time during the progress of gestation, or in the retained chorion after abortion or delivery. This hyperplasia is essentially due to a proliferation of the syncytium, the growth of the stroma being secondary. When the growth is toward the uterine cavity, it may be termed a benign placental polyp (fleshy mole, placentoma, etc.). If the newly formed villi consist of fibrous connective tissue a fibroid placental polyp is produced which has been called fibroma chorii. The hyperplasia is, however, most frequently associated with a myxomatous degeneration of the stroma of the new villi. This may involve a limited number of villi or the entire chorion (hydatid mole, vesicular mole, grape mole, bladder mole, myxoma chorii, etc.). The myxomatous change begins in the centre of the villus, while at the same time there is a peripheral growth of the syncytium and subsyncytial layer. As a result of this coincident proliferation and degeneration the villi come to appear as small cysts or bladders filled with a mucin-containing fluid, which are strung together by delicate pedicles in a manner suggesting bunches of grapes or resembling the variety of seaweed known as bladder wrack. The individual cysts have a diameter of 0.1 mm. or greater, and are fastened to slender pedicles which arise from other cysts or directly from a chorionic stem, which as a rule shows much less change. The cyst walls are very thin and delicate. Microscopically the cysts are found to be much-changed villi, the central portion consisting of a cavity filled with a serous or mucin-containing fluid, through which a few strands of stroma remain preserved. Toward the periphery there is a transition into a more dense myxomatous tissue, while just beneath the syncytium there is a thin layer of stroma of normal type. If the degeneration of the stroma occurs early in the development of the villus, the stroma may become entirely fluid; but if later, fibrous threads remain, giving an appearance more nearly resembling œdematous tissue than myxomatous. According to Marchand, no mucin is found in the cysts, the process being a hydropic rather than a myxomatous degeneration. The ends of the degenerating villi are either free or fastened to the uterine wall. If these infiltrate the wall, the hydatid mole may take on a malignant character and should then be classed as a malignant syncytioma. The causes of the hyperplasia and degeneration are unknown. It may be assumed that after the death of the fœtus the excess of nutrition supplied to the chorion leads to increased formative activity on the part of the syncytium, and the degeneration of the stroma may be due to an inability of the latter to keep pace with the former in proliferation. Hemorrhages from the decidua frequently accompany the proliferation of the villi, and large masses of fibrin may be formed around the new villi (fibrin mole). Though these chorionic hyperplasias most frequently follow abortion and delivery, they may begin during the course of an apparently normal gestation and lead to abortion. After the death of the fœtus the growth may continue indefinitely, and may at any time assume malignant characteristics. They may also arise in the vagina or in the cyst walls of ectopic gestations, wherever chorionic villi may be retained after death of the fœtus. Since by some writers the syncytium is regarded as being ectodermal in origin, the various forms of benign moles have been styled benign chorio-epitheliomata, since in all cases it is the syncytium which governs the development of the stroma. These growths must then be placed among epithelial tumors, as the process is essentially a syncytial overgrowth; and not among connective-tissue tumors with which they were formerly classed.

Syncytioma Malignum (*Chorio-Epithelioma*).—Since the chief factor in the formation of the hydatid mole is the proliferation of the syncytium, this growth bears a close analogy to an adenoma, and when the syncytial buds and cells infiltrate the maternal tissues, giving rise to metastases, it becomes carcinomatous in nature. The histological structure of the mole does not in itself give evidence of its benign or malignant character. Apparently benign moles may give rise to metastases, while, on the other hand, transported villi may fail to give rise to new growths. The behavior of the transported villi is governed solely by the covering epithelium. Marchand distinguishes between two forms of chorio-epithelioma, typical and atypical. In the former the chorionic epithelium appears as in the early months of gestation, consisting of irregular, branching plasmodial masses. In the atypical form the cells are irregular and compact, with very large and deeply stained nuclei, and while multinuclear cells are present there are no continuous plasmodial masses. The atypical form, when infiltrating, may resemble either sarcoma or carcinoma, but in the secondaries no stroma is formed as in carcinoma. Intravascular growths may occur, and either lymphogenous or hæmatogenous metastasis. Secondaries are most frequently found in the vaginal walls and lungs, but occur also in the liver, spleen, etc. The combination of branching plasmodial masses, the presence of cells corresponding to those in Langhans' layer, the absence of blood-vessels and connective-tissue cells in the intravascular growths are characteristics seen only in growths arising from chorionic epithelium.

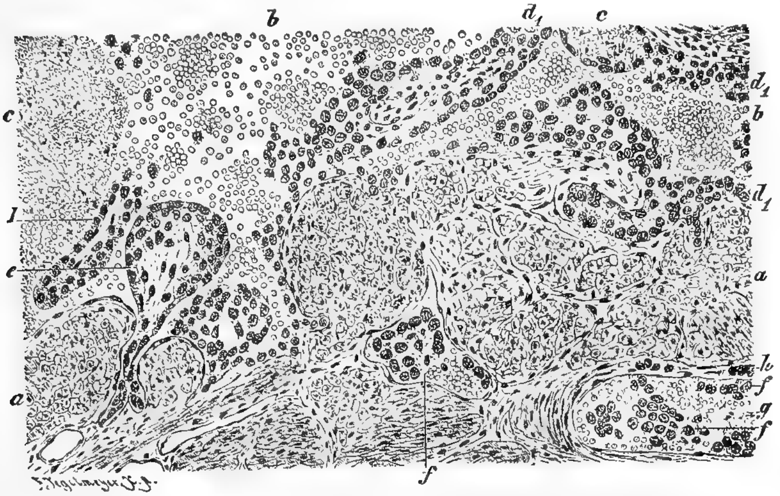

FIG. 1303.—Syncytioma Malignum. Infiltration of muscle of uterine wall by atypical plasmodial masses arising from the chorionic syncytium. (After Ziegler.)

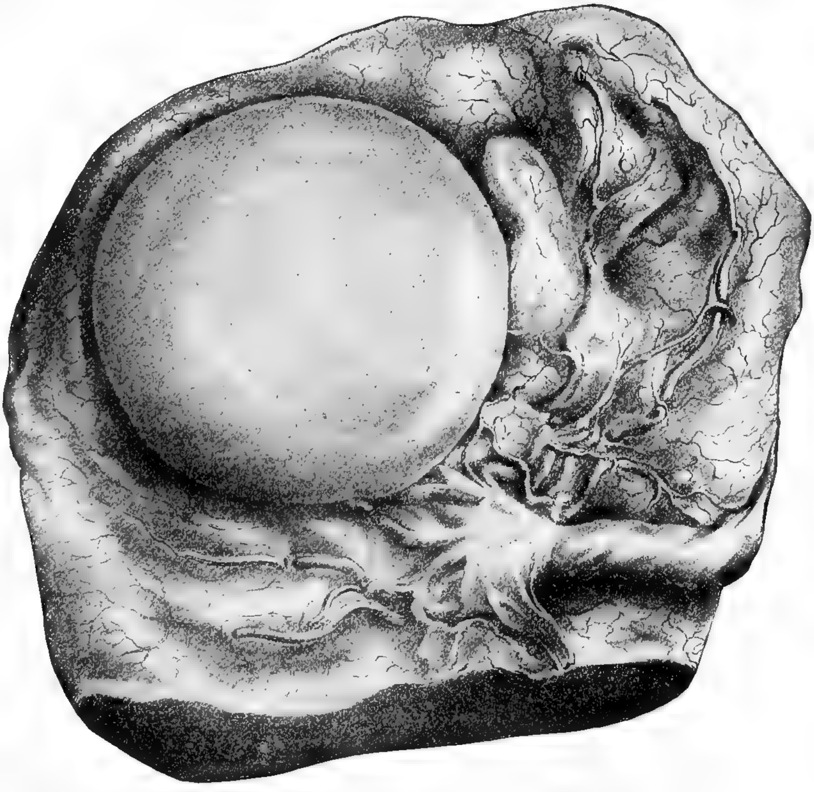

FIG. 1304.—Cyst of Chorion. (After Fenomenow, *Arch. f. Gyn.*, Bd. xv.)

The weight of authority at the present time accords to the syncytium a fœtal and ectodermal origin. The ectodermal nature of Langhans' layer seems to be definitely established, and between it and the syncytium there exist transitional forms which point to a common origin for the two layers. The term chorio-epithelioma would then seem to be justified. Both the hydatid mole and the chorio-epithelioma arise as a result of the increased formative activity of the chorionic epithelium caused by the increase of nutrition occurring after the death of the fœtus. The normal inhibition being thus removed, the syncytium may continue to grow indefinitely and in an atypical manner. Its cells become loosened and through chemotaxis enter the maternal vessels giving rise to metastases. The necessity of an early removal of all retained placentas is therefore clearly indicated, as malignant changes may occur at any time.

Connective-Tissue Tumors.—The number of reported cases of circumscribed connective - tissue growths of the chorion is very small, only 36 having been observed up to the present time. Of these 14 were diagnosed as *myxoma fibrosum*, 10 as *fibroma*, 9 as *angioma*, 2 as *sarcoma*, and 1 as a *hyperplasia* of the villi. Of these the two diagnosed as sarcoma showed no evidences of malignancy, and the one designated as hyperplasia was described as a circumscribed tumor. It is probable that these three belong to the same class as the others, and the similarity of all these growths in structure would make the diagnosis of *angioma fibro-myxoma* applicable to all. In the case of all these tumors it has been shown that the chorion is the seat of growth, and that neither decidua nor amnion is concerned in their origin; further, that the tumor arises from one cotyledon, even when multiple, having but one artery and vein. No degenerative changes were found in the remaining portion of the chorion that could be in any way associated with the origin of the growth. According to Albert these circumscribed chorionic tumors arise not from the degeneration of an existing cotyledon, but represent an atypical proliferation of a portion of the allantois, which through some unknown error of development has failed of normal growth, and retaining its embryonic impulse to proliferation leads to the formation of an atypical mass which may consist chiefly of myxomatous tissue (myxoma), connective tissue (fibroma), branching vessels (angioma), or of combinations of these. If the resulting formation is very cellular, it may be taken for a sarcoma, but has not the malignant characteristics of this form of growth. No name has as yet been proposed for these growths which will indicate both their origin and nature.

Cysts.—Aside from the cases which are very evidently to be classed with the hydatid mole few cysts of the chorion have been reported. These have been large thin-walled cysts filled with a clear fluid, situated on the fœtal surface. In a few an epithelial-like lining has been observed. According to Jaquet, four varieties of placental cysts are found: Gelatinous, arising from the space between the chorion and amnion, perivascular cysts, blood cysts, and degeneration cysts of the villi. Hegar and Maier believe that chorionic cysts may arise from the encapsulation and absorption of old hemorrhages. They may also arise from the simple softening of infarcts or as a sequel of chorionitis. Further, cysts may arise from disturbances in the development of chorion and amnion. In the case of the large monolocular chorionic cysts the cause and manner of formation are wholly obscure.

Parasites.—The micro-organisms found in the maternal circulation will appear in the blood of the maternal sinuses. It is a question whether these are able to pass through a perfectly normal and intact syncytium, but the present opinion is that the chorionic epithelium in a normal state acts as a barrier to the passage of organisms from the maternal blood to that of the fœtus. Some lesion of the syncytium, such as necrosis or desquamation, seems to be necessary for the passage, and this injury may be caused by the organisms themselves or be due to other causes. In the human species the bacilli of tuberculosis, typhoid and cholera, the pus cocci, pneumococcus, recurrens spirillum have been known to have passed through the chorion and to have infected the fœtus. The virus of smallpox, scarlatina, and syphilis may pass through the placenta, either with or without apparent local changes. In the case of tuberculosis the bacilli may be found in the fœtus when none can be demonstrated in the chorion. The important problems associated with placental transmission of disease have as yet been barely touched upon, and remain a ripe field for future investigations.

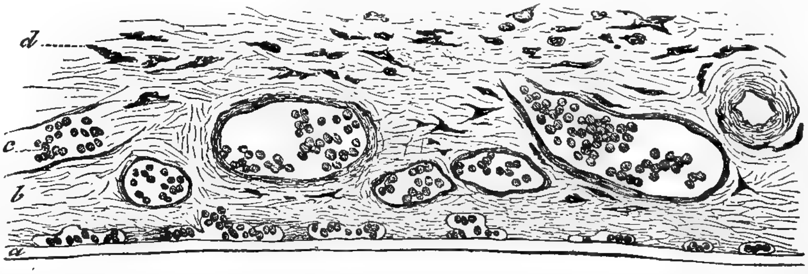

FIG. 1305.—Section of Choroid. (From Quain, after Cadiat.) *a*, Membrane of Bruch—the choriocapillaris is just above it; *b*, vascular layer; *c*, vein with blood corpuscles; *d*, lamina suprachoroidea.

Eclampsia.—Schmorl has observed in this disease the presence of emboli of giant cells in the pulmonary vessels, which he considers to be of syncytial origin. According to his theory these emboli give rise to multiple thrombosis of the pulmonary vessels, which are the direct cause of the eclampsic convulsions. This theory cannot at present be said to stand upon a very secure foundation. It is possible that in some of the cases of eclampsia in which pulmonary emboli of giant cells have been observed the giant cells were of bone-marrow origin and not placental, inasmuch as the differential diagnosis between placental giant cells and those of the bone marrow is impossible except in those cases in which large syncytial masses are present. Emboli of placental cells have been observed in cases in which there were no symptoms of eclampsia. Further, multiple thrombosis of the lungs produced by multiple emboli of liver cells does not give rise to eclampsic symptoms. The whole question of placental-cell embolism is at present somewhat unsettled. Infarction, hemorrhage, fatty degeneration, etc., of the chorion have also been believed to bear a causal relation to the phenomena of eclampsia.

Abortion.—The minute pathology of abortion is for the chief part an unknown field. Fatty degeneration, infarction, hemorrhage, calcification, myxomatous degeneration, etc., have in many cases been supposed to have been the exciting factor of the death and expulsion of the fœtus. Just what relation these changes actually bear to the production of abortion it is at present impossible to say. In the majority of cases we are unable to say whether the placental changes are primary or secondary. The association, however, of these changes in the chorion with a relatively large number of cases of abortion makes it possible that when present to an excessive degree they may lead to abortion. *Aldred Scott Warthin.*

CHOROID, DISEASES OF.—ANATOMICAL CONSIDERATIONS.—The choroid is of mesoblastic origin; in connection with the ciliary body and iris it forms the vascular tunic of the eye. It originates as a differentiation of mesoblastic formative cells over the outer surface of the secondary eye vesicle; its first appearance being manifested by a plexus of capillaries lying next to the outer surface of the secondary eye vesicle. These capillaries eventually form the choriocapillaris. At first indistinguishable from that portion of the mesoblastic tissue which later becomes sclerotic, it soon becomes differentiated, its principal structure being separated from the sclera by the perichoroidal lymph space. The choroid extends throughout the whole of the posterior part of the globe, its anterior boundary being the ora serrata. The choroid consists of five layers, which, from without inward, are:—

First, *the suprachoroid layer*, consisting of a few non-vascular lamellæ of pigmented fibres which remain attached to the sclera when the choroid is torn from it. Numerous trabeculæ pass from the lamina suprachoroidæa to the layer of large vessels traversing the suprachoroidal lymph space.

Second, *the layer of large vessels*, which contains large arterial and venous trunks, numerous nerve fibres, and connective-tissue stroma throughout which are scattered many pigmented branching cells.

Third, *the elastic layer of Sattler*, a thin, rather dense layer composed largely of elastic connective-tissue fibres.

It lies between the layer of large vessels and the choriocapillaris.

Fourth, *the choriocapillaris*, a layer of capillaries which anastomose freely, forming a close network. The capillaries are most dense at the yellow spot, the meshes becoming larger as the periphery is approached. The choriocapillaris is continuous through the entire area of the choroid. The capillaries anastomose with those of the optic nerve, but never with those of the retina. The function of this layer is to supply nourishment to the posterior layers of the retina.

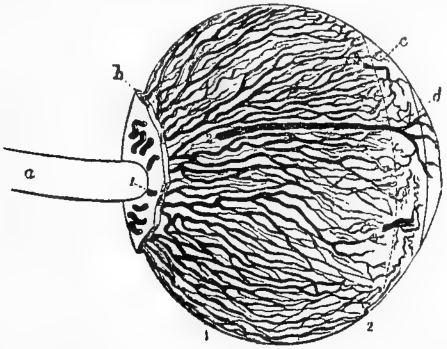

FIG. 1306.—Lateral View of the Arteries of the Choroid and Iris. (From Quain, after Arnold.) *a*, Optic nerve; *b*, part of the sclera left behind; *c*, region of ciliary muscle; *d*, iris; 1, posterior ciliary arteries piercing the sclera and passing along the choroid; 2, one of the long ciliary arteries; 3, anterior ciliary arteries.

Fifth, *the lamina vitrea*, a thin homogeneous membrane separating the pigment layer of the retina from the choriocapillaris.

Blood Supply.—The blood supply to the choroid is by the short posterior ciliary arteries, twelve to fifteen in number, which pierce the sclera diagonally about the optic nerve. On reaching the choroid they anastomose rather freely in the layer of large vessels, sending numerous small branches to the choriocapillaris into which the arterial blood flows. About the optic nerve the arteries form a vascular circle, known as the circle of Haller, from which some small branches pass to the retina. Anteriorly they anastomose with the anterior ciliary arteries. The blood is returned from the choriocapillaris by numerous small veins, which pass to larger venous branches in the layer of large vessels. The veins anastomose very freely and finally converge to form from four to six large veins, known as the venæ vorticosæ, which pierce the sclera at the equator of the globe, emptying into the large venous trunks of the orbit.

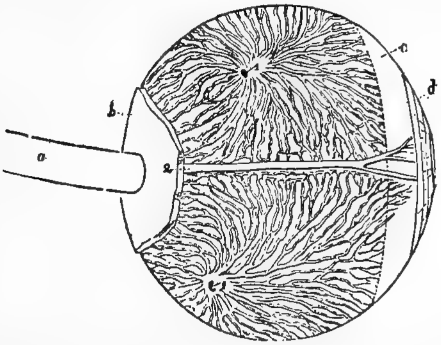

FIG. 1307.—Lateral View of the Veins of the Choroid. (From Quain, after Arnold.) 1, 1, Two trunks of the venæ vorticosæ at the place where they leave the choroid and pierce the sclerotic coat. The other lettering is the same as in Fig. 1306.

The amount of pigment present in the pigmented cells of the choroid, as in the pigment layer of the retina, differs largely in different individuals. In the blond it is relatively scanty, in the brunette and negro very dense. In the albino the pigment is wanting and, by means of the ophthalmoscope, the larger veins and arteries of the choroid can be distinctly seen.

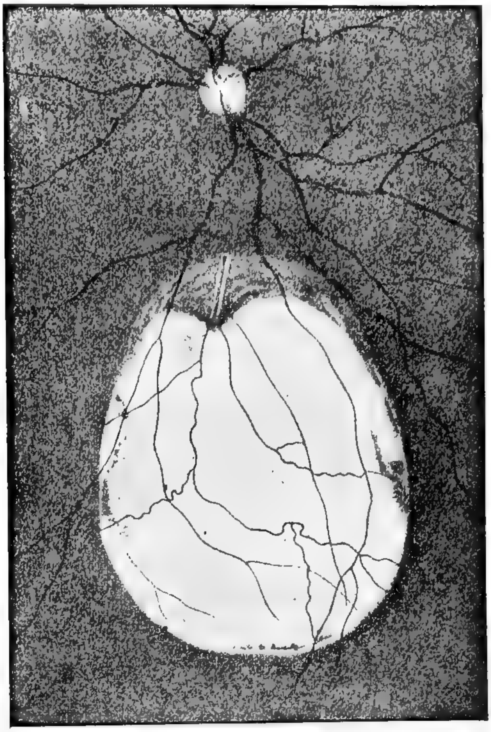

FIG. 1308.—Coloboma of the Choroid. (Haab.)

CONGENITAL ANOMALIES.—*Coloboma of the Choroid* is a defect which is usually situated in the lower part of that membrane. It is primarily due to imperfect closure of the retinal fissure in the development of the eye and the consequent imperfect formation of the choroid over the secondary eye vesicle. The retinal fissure, which begins to close at its posterior extremity, should be completely closed by the end of the second month of fœtal life; it may be arrested at any stage of development; hence the various differences in shape seen in coloboma of the choroid. The defect is usually separated from the optic disc by a bridge of normal choroid; it broadens out and ex-

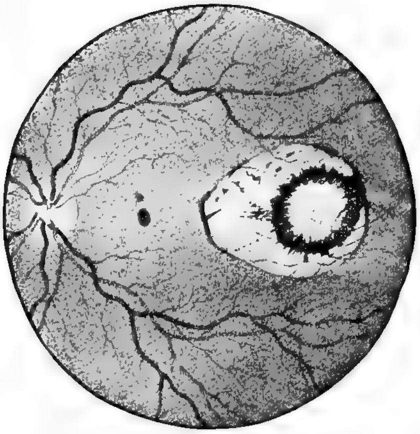

FIG. 1309. — Macular Coloboma of the Choroid. (De Wecker and Masselon.)

tends toward the ciliary body. The border of the defect is irregularly pigmented. The anterior layers of the retina pass over the defect, but all perceptive elements are wanting. Viewed with the ophthalmoscope the defect presents a pearly-white appearance traversed by a few retinal vessels. Coloboma of the iris not infrequently accompanies coloboma of the choroid, and coloboma of the lens is sometimes observed. Bulging of the sclera at the site of the coloboma is sometimes present; this may assume the character of a cyst. The globe in these cases is frequently microphthalmic. Imperfect development of the central nervous system and of the cranium is sometimes observed in these cases.

Extra-Papillary Colobomata are sometimes seen. These are irregularly circular in shape and are generally located in the macular region. So often is this the case that they are termed macular colobomata. Various theories have been advanced to explain the origin of these defects, but none of them has been substantiated. Angio-cavernomata are sometimes observed as congenital defects in the choroid. They may occur in any part of the membrane.

Hyperæmia of the Choroid.—This condition is undoubtedly present much more frequently than it is recognized. Hyperæmia of the choroid is present under the following conditions: In congestion of the head; as the first evidence of a general or localized inflammation of this part of the eye; as an accompainment of an exudative retinitis; and as a symptom of either leucocythæmia or pernicious anæmia. A deepening in the color of the fundus and slight reddening of the optic disc accompany this condition; however, unless one eye alone is affected, the change in the appearance of the fundus is so slight that it is impossible to diagnose it by means of the ophthalmoscope. It is held by some writers that hyperæmia of the choroid is accompanied by certain subjective symptoms, such as meteoric flashes of light, wavy effects like those produced by the atmosphere when radiated from a heated surface, and at times photopsia. These phenomena are due to disturbance of the perceptive elements of the retina, and, as they often precede destructive processes, they should be given careful attention.

Choroiditis.—The term choroiditis is not sufficiently comprehensive to include all of the pathological processes which affect the choroid, since not all of the processes are inflammatory. It is therefore logical to divide the affections of the choroid into inflammatory and non-inflammatory; to the first the term choroiditis properly applies, to the second the term choroidal atrophy applies. All forms of choroiditis are exudative; for convenience they may be divided into non-suppurative and suppurative. The non-suppurative forms include the sero-plastic, plastic, disseminate, diffuse, areolar, circumscribed, hemorrhagic, sclero-choroiditis anterior, and some forms of central choroiditis.

Causes. The causes of choroiditis are the same in all except the embolic or metastatic, the purulent, tuberculous, traumatic, and atrophic forms, and may be considered before descriptions of the various forms are given. The most frequent cause is syphilis, either inherited or acquired. That due to inherited syphilis (which is by far the most frequent cause) is often discovered only after the clearing up of an interstitial keratitis. It is probable that in some cases the choroidal disease precedes the corneal, but no doubt the reverse is true also in many cases. The choroiditis of acquired syphilis may follow the initial lesion in a few months, but it is rare at so early a period; it may occur years later. In all but the sero-fibrinous and retino-choroidal forms the choroidal lesion due to syphilis is circular in shape, and in some forms of disseminate choroiditis the arrangement of the spots suggests the papillary syphilide as observed on the skin. Rheumatism and gout may account for some of the cases of choroiditis for which syphilis, as a cause, cannot be traced. The history is apparently sufficient in some cases to warrant this supposition, and the treatment by the salicylates is sufficiently productive of results to sustain the opinion. Leprosy is, according to Knies, a cause of irido-choroiditis in rare cases. Gonorrhœa in a very few cases is undoubtedly the cause. The form produced is the sero-fibrinous variety, with involvement of the whole uveal tract. Relapsing fever is sometimes accompanied by a diffuse, sero-plastic anterior choroiditis; typhoid fever is also sometimes a cause of this form of choroiditis.

Sero-Plastic Choroiditis.—This disease is characterized by a relatively sudden onset and the appearance of a sero-fibrinous exudation in the vitreous. The same exudation is present in the posterior and anterior chambers in many cases. There are more or less congestion of the deep vessels of the ocular conjunctiva and diminution of vision.

Symptoms. Unless the ciliary body or iris is involved no pain is experienced in the cases which do not result in increase of tension. Acute glaucoma may supervene. If this occurs the pain becomes intense. The vitreous becomes filled with minute particles of fibrin which obscure the view of the fundus, and the aqueous may be invaded by the particles which often become attached to the posterior surface of the cornea in the form of a pyramid. The vision is correspondingly obscure. Photopsia is not a prominent symptom. The anterior chamber is shallow because of an increase in the contents of the vitreous chamber. The pupil is moderately dilated.

Course. The disease runs its course in from six weeks to as many months. The opacities in the aqueous humor gradually disappear. Those in the vitreous may entirely disappear, but in many cases some large shreds of exudation remain and are movable in the vitreous, indicating a partial fluidity of that body. No evidence of changes in the choroid is discernible in some cases; in others some atrophic patches at the periphery may be seen after the acute stage has passed. In some cases vision returns to the degree of acuity present before the inflammation began, in others there is a permanent partial loss. If atropine is not instilled, adhesion between iris and anterior lens capsule may occur and the synechiæ become permanent. Recurrence is not uncommon.

Pathology. In this form of choroiditis pericorneal injection is sometimes found; the choroidal vessels are engorged with blood. The choroid is slightly œdematous. The exudation contains some fibrin. When the acute stage has passed there may be little change in the choroid, but in not a few cases slight atrophic changes occur, affecting the choriocapillaris principally.

Treatment. Quite vigorous antisyphilitic treatment is indicated in all cases which are not clearly attributable to some other disease of the system. If there is reason to believe that a rheumatic element is present, the salicylates and the bicarbonate of soda may be employed. It is not wise to omit antisyphilitic treatment even if no history of syphilis can be elicited. The effect of potassium and mercury to prevent plastic formations is valuable in the non-syphilitic as well as in the syphilitic cases. Iron tonics are also of value. If the tension of the eye is not increased, it is necessary to apply atropine locally. The solution of this drug should be instilled sufficiently often to prevent the formation of posterior synechia. It is better to have the patient remain in bed until the acute stage of the disease has subsided. Leeches and cold or hot applications are of doubtful value.

Chorioretinitis Syphilitica.—Since in all forms of choroiditis the retina is more or less implicated, it would be more exact to include the retina in all of the terms used to indicate the different forms of choroiditis; but as the involvement of the retina is not a striking part of the picture portrayed by the disease in many of the forms of choroiditis, that membrane is not mentioned. Some of the forms involve the retina very seriously, and to one of these the term chorioretinitis syphilitica is given; to another, the term chorioretinitis pigmentosa is applied. Chorioretinitis syphilitica is a disease closely allied to sero-plastic choroiditis, although it produces more permanent damage to both membranes than does the latter.

The diffuse haziness of the vitreous is present usually to a moderate extent, shreds of exudation appear in the vitreous, and isolated large or small spots of exudation occur in the choroid. The retina appears hazy because of œdema, and retinal hemorrhages may occur. The evidence of perivasculitis of the retinal and choroidal vessels is unmistakable. The vision is greatly diminished, and flashes of light, photopsia, micropsia, and macropsia may be experienced. Slight injection of the ocular conjunctiva may occur in the acute stage. Pain is not present. In many of these cases the diagnosis can be made at any stage of the disease, as the vitreous remains sufficiently transparent to permit of a more or less satisfactory examination of the fundus. The exudation into the choroid and retina is serous and plastic. The plastic exudation, which takes place in the form of circular patches, undergoes the same changes as those which characterize the exudation of disseminate choroiditis; atrophy being the terminal stage in both cases. As a result of plastic exudation in the retina, cicatricial bands may develop in that membrane, and they may also develop in the vitreous, in the plastic exudation that sometimes extends into that part of the eye. Detachment of the retina as a result of the traction of cicatricial bands in the vitreous is rare, owing to the fact that the choroid and retina are adherent in many places; but detachment of the choroid and retina together is sometimes seen following degenerative changes in the vitreous. A cataractous condition of the lens and atrophy of the globe are rare results.

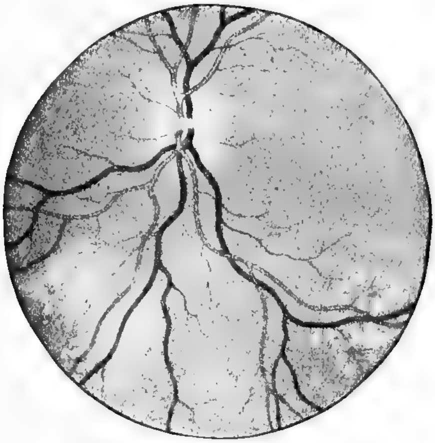
FIG. 1310.—Syphilitic Chorioretinitis. (De Wecker and Masselon.)

The inflammatory stage usually responds quite readily to treatment, but the treatment must be vigorous and long continued.

Diffuse Choroiditis.—This form of choroiditis is characterized by the appearance, in the choroid, of large pale plaques of exudation which are found to be most extensive at the periphery. These patches at first are of quite a uniform orange or pale yellowish-pink color, not bordered by pigment. The retina over the areas of exudation is slightly œdematous. The patches coalesce, forming irregular areas with indentations of the normal fundus. The forms assumed have been likened to continents and islands and have been termed "map-like." Sometimes they assume the shape of leaves, which has caused them to be termed "leaf-like."

The disease is extremely slow in its development. The exudate slowly appears and as slowly disappears, leaving irregular scanty pigmentation over the affected areas and in some places a little pigmentation at their borders. The pigment layer of the retina and the superficial layer of the choroid, the choriocapillaris particularly, undergo atrophy and disappear. The deeper layers of the choroid remain nearly if not quite intact. There may also be found evidences of perivasculitis and occasionally of almost complete conversion of the larger vessels of the choroid into connective-tissue bands. By ophthalmoscopic examination the larger choroidal vessels and the deep choroidal stroma can be readily seen. The retinal vessels in severe cases become reduced in size, and the optic disc presents hazy edges and becomes slightly pale, giving evidence of partial secondary atrophy of the optic nerve.

Individuals thus affected almost always present the stigmata of inherited syphilis.

Symptoms. The patient experiences no pain nor is there any injection of the external ocular tissues. Night blindness is sometimes experienced, and there is limitation of the visual fields in the parts corresponding to the affected areas of the choroid.

Prognosis. The prognosis for recovery of vision is not good, but much can be done to prevent the further advance of the disease. Treatment is similar to that of disseminate choroiditis.

Disseminate Choroiditis.—This form consists in the development of foci of exudation which are spread out over a large part, often the entire fundus, in the shape of circular patches which vary in size, but as a rule average in diameter less than that of the optic disc. After a time the exudation becomes absorbed or changed into fixed products, and atrophic areas occupy the site of the areas of exudation. The disease may for convenience be divided into two stages—the acute and the stage of atrophy.

The Acute Stage.—In the early part of the acute stage circular spots of exudation appear in certain parts of the fundus, usually beginning at the periphery; they are paler than the surrounding normal fundus. These spots have not very sharply defined borders. The retina immediately over the masses of exudation is not elevated, as may readily be determined by examination with the ophthalmoscope, but there is often an invasion of the retina by the exudate, as evidenced by the hazy appearance of the retina at these points. The spots multiply in number if not interfered with, resembling in many cases the groupings of papillary syphilides as they appear on the skin. The areas of exudation are primarily discrete, but may eventually coalesce. The greater part of the fundus may become studded over with these spots of exudation in the course of two or three weeks, but in not a few cases some of the spots will be found to have passed to the second stage when others have but just appeared.

Ordinarily the cornea and media remain clear, but in some cases a parenchymatous keratitis may occur at the time of the onset of the choroiditis, and the presence of the affection of the choroid may not be discovered until the cornea again becomes clear.

The Stage of Atrophy.—The first stage passes slowly into the second stage. Gradually the exudation disappears, the spot becomes paler, and the border of the affected area ordinarily becomes irregularly pigmented, the pigment being heaped up at certain points. Flecks of pigment are often observed over the area of the spot itself. Entire absence of pigment is not infrequently observed. The exudate either entirely disappears or a portion is converted into cicatricial tissue. All degrees of change

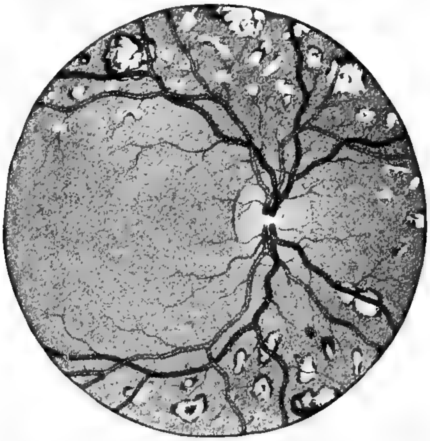
FIG. 1311.—Disseminate Choroiditis. (De Wecker and Masselon.)

may occur in all the layers of the choroid, from slight impairment to complete atrophy, with a disappearance of all vessels and, the presence of cicatricial tissue, which, lying over the exposed sclera, presents a whitish patch, tinged slightly with yellow, in the fundus. The pigment changes noted are due to destruction and more or less complete disappearance of the retinal and choroidal pigment of the part affected. The peculiar arrangement of pigment at the border of the spot is due to deposits of retinal pigment which in some cases is apparently increased in quantity. In many cases not interfered with by treatment, the affected parts coalesce and form large areas; it is also known that atrophic spots may enlarge and affect increased areas without the appearance of fresh exudation, probably because of the interference with the nutrition of adjacent tissues.

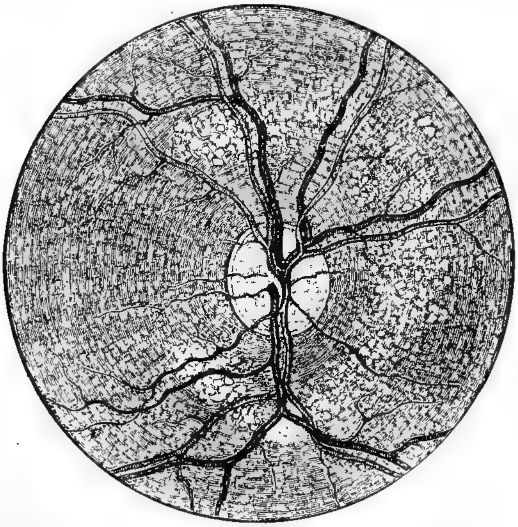
FIG. 1312.—Guttate Choroiditis. (De Wecker and Masselon.)

Symptoms. These are common to all forms of choroiditis—namely, loss of vision in portions of the fields of vision corresponding to the affected areas, and diminution of vision in contiguous parts from impairment of nutrition. Photopsia is manifested variously during the acute stage; there is slight photophobia in the acute stage in some cases.

Duration. The acute stage, if not interfered with, may last for a period of years; as a rule the exudation disappears in from six months to two years, and the stage of atrophy takes possession until the end. Fresh outbreaks of exudation may occur. A choroid that has remained quiet for years may present recent foci of exudation.

Results. More or less atrophy follows the disappearance of the exudation, the atrophy affecting not only the choroid but also the posterior layers of the retina. Destruction of the choriocapillaris probably always occurs at the point of exudation. With destruction of this layer the posterior layers of the retina, including the perceptive layer, are deprived of adequate nutrition and degenerate, and cicatricial tissue is found not only in the choroid but often involving the deep layers of the retina. Impairment of the retina, if extensive, results in atrophy of many of the afferent nerve axis cylinders and consequent partial atrophy of the optic nerve. The portions of the retina that are sufficiently nourished will preserve the axis cylinders which go from them. Following the impairment of nutrition degenerative changes in the vitreous and in the crystalline lens take place, these changes corresponding in degree to the impairment of the nutrition.

Treatment. Much can be accomplished by vigorous judicious treatment in the acute stage of disseminate choroiditis, but nothing of importance can be done to correct the condition when the atrophic stage has been reached. The treatment is almost wholly constitutional. The exudation is due to localized perivasculitis, usually of syphilitic origin, and must be treated as such. Mercury and potassium are the remedies on which most reliance can be placed. Iron should also be given. Nourishing diet must be insisted upon. Rest in bed is valuable in the early part of the acute stage. The use of colored glasses and the prohibition of the use of the eyes for close work should be enjoined. In the acute stage mercury by inunction, by the stomach or hypodermically, should be given to saturation and potassium iodide until the physiological effects are obtained. These remedies should be continued, a little short of saturation, until the exudation has very nearly or quite disappeared. The treatment in a less vigorous manner should be continued for six months to two years, according to the exigencies of the case.

Choroiditis Areolaris (Foerster).—This form is probably a variety of choroiditis disseminata. It usually begins at or near the posterior pole of the eye and first presents itself as a plaque of pigment. Soon the centre of the plaque thins and presents a lighter color. The light centre enlarges and we eventually have an atrophic patch surrounded by a relatively broad border of pigment. These patches coalesce and form rather large, irregular patches situated at or near the posterior pole of the globe; exceptionally they are found at the periphery. There are seldom more than two or three patches.

This form of choroiditis is met with in young children, and is thought to be congenital in some cases. It develops also at all ages. There may be few or many patches. The vision may remain very good for a number of years. It may fail quite suddenly without apparent cause.

Treatment. The same as in disseminate choroiditis.

Guttate Choroiditis (Hutchinson and Tay).—The region of the macula is occupied by a number of small, whitish or yellowish dots which resemble the deposits that occur in the deep layer of the retina in albuminuric retinitis, but are more yellow and are circular. They seldom reach more than one-fourth the diameter of the disc and are often very minute. These spots may be very numerous. They do not tend to disappear; on the contrary, they continually increase, but produce no impairment of vision. This condition is due to the formation of excrescences on the lamina vitrea which project into the retina. They are peculiar to advanced life. These spots are often observed scattered more or less densely over the entire fundus.

Treatment is of no avail.

Embolic Choroiditis; Metastatic, Plastic, and Suppurative Choroiditis.—Embolism of one or more choroidal vessels probably occurs more frequently than is recognized. The dozen or more small arteries that pierce the sclera anastomose freely when they reach the choroid; consequently the plugging of one artery can make but little difference with the circulation in this membrane. If the plug that enters a short ciliary artery does not contain pathogenic germs the disturbance occasioned is slight.

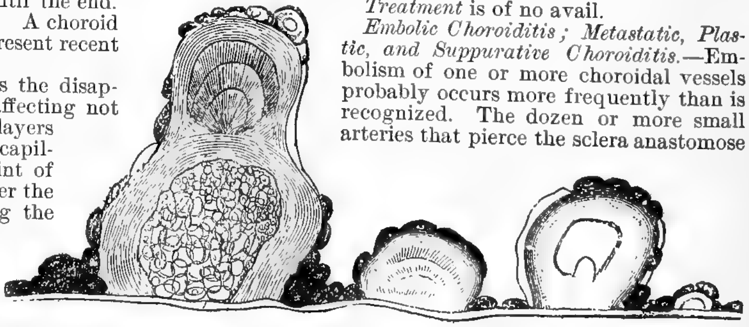
FIG. 1313.—Excrescences on the Lamina Vitrea, in Guttate Choroiditis. (De Wecker and Masselon.)

Knapp (*Arch. f. Oph.*, xiv., 1) described two cases of simple embolism in which the onset of the symptoms was quite sudden. The patient noticed a blurring of vision which at first included the whole field, but later became confined to the central portion. In one case the vision equalled one-tenth, in the other case the patient could read the finest print; the patient noticed a large scotoma lying near the axis of vision. There were marked chromatopsia and photopsia. On ophthalmoscopic examination a circumscribed cloud or veil was observed in the central portion of the fundus corresponding to the scotoma, which involved the retina and had extended to the disc. The condition was evidently due to embolism of some of the choroidal vessels at this point, the effusion and hyperæmia following as a result. In each case vision was completely restored. Each patient had well-marked cardiac disease. Not infrequently, from a suppurative process taking place in some distant part of the body, a minute mass of pyogenic or pathogenic micro-organisms enters the circulation and is conveyed to the choroid on one or both sides; there will then be set up a plastic or suppurative choroiditis. Ulcerative processes located in the alimentary canal or in the genital tract, or affecting the cutaneous surface or any other part of the body, may be the foci from which micro-organisms proceed by way of the blood to the choroid; when this takes place the processes just alluded to are established. Direct extension from the meninges of the brain to the eye is said to occur (Wells, the American edition, p. 542). Metastasis may occur in cerebrospinal meningitis, puerperal fever, pyæmia, smallpox, pneumonia, erysipelas, cholera, and malignant pustule. It has been met with in ulceration of the umbilical cord in the new-born. Plastic choroiditis and tuberculous choroiditis are seldom due to injury, but suppurative choroiditis is frequently the result of perforating wounds of the eyeball as well as of metastasis.

Plastic Choroiditis.—The onset of this disease is similar to that of purulent choroiditis, but is not quite so severe. The vitreous becomes hazy; the anterior chamber usually shallow, but sometimes deepened; the ocular conjunctiva hyperæmic. The iris is bound down to the anterior capsule. During the first stage there is pain, which is of a dull, continuous character. The vision at an early stage is soon reduced to perception of light only and may fail entirely. Soon a yellowish reflex is observable from behind the pupil, due to the presence of plastic lymph in the vitreous chamber. The plastic lymph may fill the whole vitreous chamber or it may be spread in a layer of varying thickness over the fundus. The globe is usually soft, but in the early stage it may have a slightly increased tension. In the average case of this form of choroiditis the globe, which at first appears to be slightly distended, gradually shrinks, becoming smaller than its fellow; it maintains this shrunken condition, the vision being entirely lost. In the very mild cases some degree of vision may be retained.

Diagnosis. In the severe cases the inflammatory reaction is so marked and the progress of the case to atrophy of the globe is so unmistakable that the diagnosis is readily made; but in the milder cases the color of the reflex, the degree of tension and the size of the globe, the presence of blood-vessels, and the situation of the exudate are such that it is very difficult to separate these cases from those of glioma and other intraocular tumors. In making a differential diagnosis the history of the case in every particular must be obtained, as this is the most important factor. A history of meningitis or of some one of the eruptive fevers, or of a suppurative process just preceding or occurring at the time of the onset of the eye disease, aids much to clear up the diagnosis. Locally, adhesions between the iris and lens with a broadening of the sinus of the anterior chamber, atrophy of the iris, minus tension, reduction in the size of the globe occur in metastatic plastic choroiditis, but they are seldom met with in glioma. There may be tenderness on pressure, but this may also be present in glioma.

Treatment. In the mild cases the use of mercury and iodide of potassium seems to exert a beneficial effect by preventing plastic formations; some degree of vision may be retained in these cases. In all cases in which vision is *nil* and the question of glioma cannot be settled, or in which the globe is at all painful, enucleation may be resorted to. Recurrent inflammation may also render enucleation advisable.

Suppurative Choroiditis (*Panophthalmitis*).—Suppurative processes originating in the choroid are not confined to this membrane but involve all the tissues of the interior of the eye, often perforating the sclera or cornea. The general nature of the affection entitles it to the term panophthalmitis.

Cause. The cause is most commonly an injury, accompanied by the introduction of pyogenic or pathogenic germs. Metastasis may be the manner of infection, pus-producing micro-organisms being carried to the choroid from purulent processes occurring in distant parts of the system. The germ most often found is the staphylococcus, but the streptococcus and the pneumococcus have been found as causative factors.

Symptoms. Severe continuous pain is experienced almost from the beginning. The sight is lost very early. After the infectious material has effected a lodgment a period of from twenty-four to forty-eight hours elapses before the disease obtains sufficient headway to occasion great discomfort. Then the ocular conjunctiva becomes swollen and hyperæmic. Chemosis, sometimes to an enormous degree, causing the conjunctiva to protrude between the lids, exists. The lids are frequently enormously swollen. The tissues of the orbit also partake of this condition, causing the eyeball to bulge forward. The flow of tears is increased and some muco-purulent discharge from the conjunctiva is often observed. The anterior chamber becomes shallow and the aqueous humor turbid. A yellow reflex is often seen through the pupil. The tension is often much raised, although in some cases it is reduced. The cornea becomes gray and in many cases sloughs, permitting the escape of pus from the interior of the eye through the opening thus formed. The pain is not confined to the eyeball, but is experienced in the side of the head corresponding with the affected eye. After some days the inflammation subsides, pain diminishes, and at the end of three or four weeks the acute stage of the process terminates. The globe gradually shrinks and passes into the condition known as phthisis bulbi.

Treatment. Hot applications by means of hot water or poultices, with the administration of laxatives, is often resorted to; but the more modern treatment is to regard panophthalmitis as an abscesss or phlegmon of the eyeball and to treat it as abscess or phlegmon is treated when it occurs in other parts of the body. A crucial incision through the cornea, followed by frequent cleansing of the eye with an antiseptic solution (bichloride 1 to 5,000) and by hot poulticing, does much to shorten the process and to relieve pain. Complete evacuation of the contents of the globe (evisceration) is much better treatment in the early stage of the affection. This is accomplished by excising the cornea, removing the entire contents of the sclera by means of a suitable curette, cleansing the cavity thus formed with bichloride (1 to 2,000), packing with aseptic gauze, and bandaging. The bandage and packing are changed as often as required. This treatment, which has never resulted fatally to the patient, stops the process together with all its attendant discomforts and pain at once, and converts a pus-forming process into a surgical wound. Recovery is rapid. The cavity becomes filled with granulation tissue. Packing the cavity is to be discontinued as healing advances, and eventually the sclera and its contained granulation tissue shrink and form a small irregularly spherical mass, which is not sensitive and over which an artificial eye can be worn.

Tuberculosis of the Choroid.—It is usually due to the formation of miliary tubercles in the stroma of the choroid. It is metastatic in origin and commonly accompanies miliary tuberculous processes in other parts of the body. The disease appears most frequently in children and is more common in individuals who suffer from tuberculous meningitis. Michel (*Augenheilk.*, p. 404) puts the percentage of cases of tuberculosis of the choroid accompanying tuberculous meningitis in children at thirty-five to forty per cent. This seems to the author to be very much too high.

Symptoms. The patient complains of no pain. The condition is diagnosed by use of the ophthalmoscope. The tubercles usually appear at the posterior part of the fundus, and are not visible until they occasion disturbance of the retinal pigment layer. At first, there is observed a small spot of pigment slightly more pronounced than the surrounding fundus; this is due to slight prominence of the pigment layer over the tubercle. Soon the centre of the pigment patch takes on a pale whitish color, circular or oval in shape, due to absorption of the retinal pigment, and this reaches the size of the optic disc—sometimes a little smaller, sometimes larger. If a number of miliary tubercles are grouped together, as is often the case, the size and shape of the patch are changed. Many tubercles may be scattered over the fundus, or there may be but one or two tubercles present. Retinal vessels pass over the patch, the retina is slightly raised, and in some cases a slight local detachment of the retina occurs. Vision is but little interfered with, except in the portion of the field corresponding with the site of the tubercle, where there is a relative or complete scotoma.

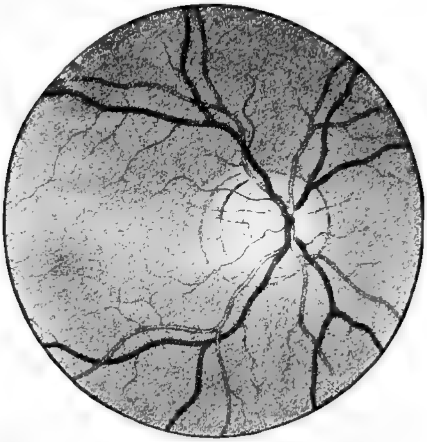

FIG. 1314.—Sclero-Choroiditis Posterior of Moderate Degree. (De Wecker and Masselon.)

Treatment. Since the patient usually succumbs to the effects of the disease in other parts of the system, nothing can be done to relieve the local condition. Large tuberculous tumors are sometimes met with in the choroid.

Hemorrhagic Choroiditis.—The vessels of the choroid, like those in other parts of the body, are from time to time the seat of disease, and their walls may become so weakened that the fluid and at times the corpuscular portions of the blood may escape into the tissue of the choroid and also beneath the retina. The escaped blood may break through the retina and enter the vitreous. The appearance presented is that of large, irregular patches of blood clot which often cause the retina to bulge forward. Through the action of gravity the upper border assumes a horizontal line, the lower border being curved. Above the clot the tissues are tinged a yellowish red by the partly absorbed blood pigment. The clot gradually becomes absorbed, leaving a white patch of atrophy with some pigment scattered over it. Choroidal hemorrhage may produce acute glaucoma.

Treatment. The treatment is restricted to the care of the general condition.

Detachment of the Choroid is rarely met with, but it sometimes follows an exudative inflammatory process in which the exudation, serous or fibrinous and large in amount, finds its way between the choroid and the sclera. It may be due to the presence of a tumor or to hemorrhage, and it may accompany a degeneration of the vitreous during the course of an irido-cyclo-choroiditis.

Non-Inflammatory Affection of the Choroid.—The atrophy accompanying myopia is rarely inflammmatory. The axial elongation of the globe in myopia is due to the thinning of the posterior segment of the sclera, and, as shown by the ophthalmoscope and by post-mortem section, the greatest stretching of the sclera takes place at or near the optic disc. The change in the tissue of the sclera is not accompanied by any infiltration of small cells (the characteristic accompaniment of inflammatory processes), nor do we find such infiltration of small cells in the issue of the choroid. The small myopic crescent is not a condition due to pathological changes in the choroid, but, as Michel has shown, the bulging of the sclera causes the optic disc to become more obliquely placed to the antero-posterior axis of the globe than is the case in the normal eye, and the transparent tissue of the optic papilla permits the white, opaque tissue of the edge of the sclera and the optic nerve sheath (usually at the inner lower quadrant of the disc) to show through. The nasal side of the disc is sharply defined, but the lower temporal side is ill-defined. In high degrees of myopia the choroid at the posterior pole of the eye suffers most; at the periphery the membrane is but little changed. The condition met with is one in which the choroid is thinner than normal. The meshes between the capillaries of the choriocapillaris and between the vessels in the layer of large vessels are enlarged. The choroidal pigment is more spread out and the retinal pigment is also rendered much less dense.

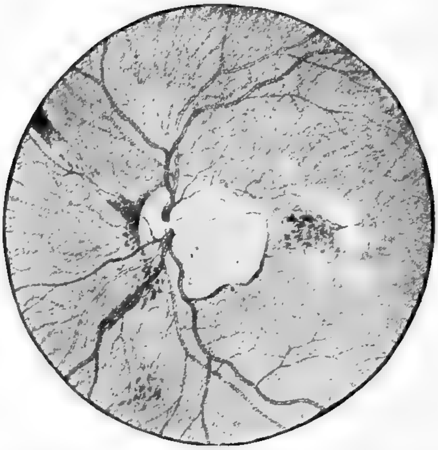

FIG. 1315.—Sclero-Choroiditis Posterior of High Degree, with Changes at the Macula. (De Wecker and Masselon.)

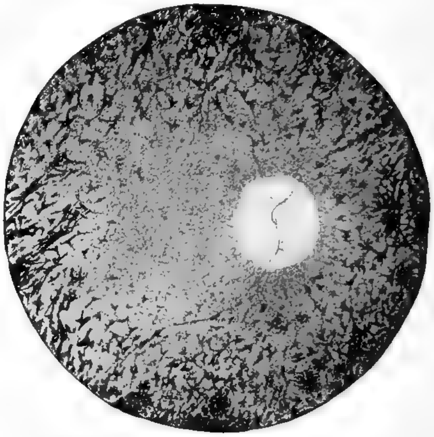

FIG. 1316.—Retinitis Pigmentosa. (De Wecker and Masselon.)

In eyes thus affected the white sclera shines through to a greater extent, giving the fundus a pale appearance, often referred to as *rarefaction* of the choroid. The stretching of the vascular tunic may be so great that small choroidal hemorrhages appear at or near the macula, and, because of atrophy of the choroid at this point, a condition sometimes known as central choroiditis is produced.

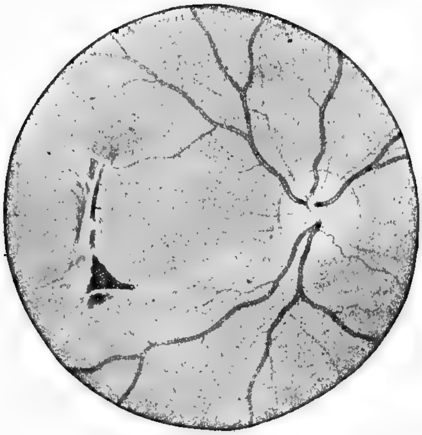

FIG. 1317.—Rupture of Choroid. (De Wecker and Masselon.)

Superficial Senile Choroiditis.—This condition is due to atrophy of the choriocapillaris, accompanying which we have a disappearance, often, of the retinal pigment and at the same time a deep atrophy of the choroid corresponding to an obliterating arteritis of some of the larger arterial branches.

Chorioretinitis Pigmentosa is an example of a non-inflammatory process. A non-inflammatory degeneration takes place, affecting the vessels of both membranes and also affecting the structure of both membranes. This atrophy proceeds from the periphery toward the posterior pole. In some cases the vascular degeneration is accompanied by an escape of portions of the blood, which may, on becoming absorbed, leave atrophic spots in the choroid, or rather spots in the choroid from which all pigment has disappeared. Ordinarily, in cases of general atrophy of the choroid, the choroidal pigment is changed but little. A change in the retinal pigment is often noticed, sometimes amounting to an hyperplasia of the pigment, as is the case when the bone-corpuscle figures are seen. Sometimes the change is of such a character that the retinal pigment is heaped up, as in cases in which a deeply pigmented margin occurs about an atrophic choroidal patch. The ganglion cells of the retina and the axis cylinders perish as the disease advances, and secondary atrophy of the optic nerve follows as a consequence.

It sometimes happens that this passive atrophy begins at the posterior pole of the choroid, and there is then produced that variety of the condition to which the name *chorioretinitis centralis* has been given. In this type of the affection the vision fails as the disease advances. If the periphery is first attacked the field of vision is narrowed concentrically; if the process first appears at the posterior pole, a relative, negative, or positive central scotoma follows. The affection under discussion is termed chorioretinitis pigmentosa or retinitis pigmentosa, according to the degree of visible involvement of the choroid. If some atrophic choroidal patches are seen the affection is termed chorioretinitis pigmentosa; if no such patches are present, the affection is supposed to involve the retina principally and is termed retinitis pigmentosa. In reality these processes are one and the same so far as their pathology is concerned. On examination with the microscope both membranes are found to be in a condition of atrophy.

Chorioretinitis pigmentosa is often congenital in origin and is sometimes accompanied by degenerative processes in other tissues of the body. It is influenced by heredity. The intermarrying of relatives is supposed to produce it, as is also inherited syphilis.

The obscure affection known as retinitis proliferans is also a disease in which atrophy of the choroid is an accompanying condition.

Traumatism of the Choroid.—It may affect the membrane in a number of ways. Hemorrhage and rupture of the choroid are frequently met with as a result of a non-perforating blow on the eye, the lesion usually appearing at a spot opposite to the point of impaction; the rupture is due to contrecoup. Hemorrhage may be from the capillaries, which is most frequently the case, or from large vessels. In rupture of the choroid the injured portion is obscured by the hemorrhage and by exudation which usually goes on for a few hours. The exudation passes into the retina and extends into the vitreous. When the exudation and blood have become absorbed, a crescentic atrophic patch is usually seen in the posterior part of the fundus, concentric to the optic disc. The retinal vessels pass over this patch, showing clearly that it affects a tissue beneath the retina. Although usually arranged in a manner concentric to the disc, ruptures of the choroid may assume almost any shape. The ruptures may be single or multiple. A scotoma is present in the visual field corresponding with the location of the rupture.

Perforating Wounds of the Choroid are of all kinds and of all degrees: perforating, lacerating, incised, clean, infected. Perforating wounds of the choroid always involve other membranes, and consideration of these must necessarily involve consideration of other parts of the eye. Clean, incised wounds, if not too extensive, will heal without destruction of the eye. If the blood clot extends into the vitreous, we may apprehend the formation of fibrous bands in the vitreous, and these may ultimately result in detachment of the retina. Infected wounds often lead to panophthalmitis.

Treatment. In rupture of the choroid from contrecoup but little can be done. It is probably best to put the patient to bed and to give remedies that will prevent the development of plastic processes or the organization of plastic products. If left without treatment the clot and exudation will become absorbed, and almost if not quite as favorable results will be obtained.

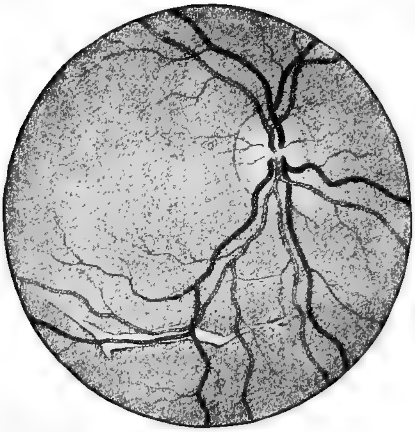

FIG. 1318.—Rupture of Choroid. (De Wecker and Masselon.)

Prognosis is favorable.

In clean, lacerating wounds the eyeball can often be saved by properly caring for it.

Infected wounds result in panophthalmitis, which should be treated as heretofore advised.

John E. Weeks.

CHROATOL.—$C_{10}H_{16},2HI$—terpin-iodo-hydrate. This occurs in greenish-yellow crystals of aromatic odor, insoluble in water, soluble in alcohol, glycerin, benzol, and acetic ether, and slightly soluble in ether and chloroform.

In ten-per-cent. ointment or powder it has been employed for psoriasis, alopecia, and other affections of the skin.

W. A. Bastedo.

CHROMIDROSIS.—(Synonyms: Ephidrosis tincta; stearrhœa or sebórrhœa nigricans; pityriasis nigricans; Fr., *Cyanopathie cutanée.*)

DEFINITION.—A disorder of the perspiratory glands in which the sweat assumes various shades of color, as blue, red, yellow.

This is an exceedingly rare disease, so rare that many doubt its existence, but so many well-authenticated cases have been reported that further doubt is scarcely warranted. On the other hand, some of the cases observed have proved to be impostures.

The disease is most frequently observed upon the eyelids, cheeks, forehead, abdomen, and scrotum. The distribution may be unilateral or symmetrical, the disease occuring in small patches. Often the affected area changes from place to place. The color varies from a yellow to a dark brown, brick-dust-like, green, blue, or red tint. There is usually mixed with the sweat a certain amount of fat which upon drying leaves an amorphous granular deposit upon the skin, and which may be partially if not entirely removed by water or ether.

Most cases have occurred in neurotic or hysterical unmarried women, in conjunction with uterine or ovarian disorders and with chronic constipation. It was formerly thought that the absorption of indican from the intestinal canal in the latter condition was the principal factor, but this has not been confirmed, as the pigment in the sweat does not give the indican reaction.

The amount of pigment in these cases varies from day to day, and may disappear for weeks or months to recur again. The disease usually lasts for years.

Green or blue sweat occurs quite frequently in workers in copper, from internal introduction of the metal.

Blue sweat has been known to occur after taking large quantities of iron and also from potassium iodide; in the latter case the blue reaction was caused by the starch in the shirt (Taylor).

Phosphorescent sweat has been observed after taking phosphorus and after eating phosphorescent fish.

Red sweat occurring in moist regions of the body like the axilla and pubes is produced by micro-organisms (Bacterium prodigiosum), and is associated with concretions on the hairs (lepothrix).

Hæmatidrosis cruenta is produced by hemorrhage into the sweat glands or ducts, causing a reddish sweat (see *Purpura*).

The TREATMENT of chromidrosis depends upon the cause. In the idiopathic forms the general condition should be treated—bowels, uterine conditions, etc.

In those cases which are due to the introduction of metals or drugs into the system the treatment is obvious.

The forms produced by micro-organisms can be easily relieved by mild antiseptic applications.

William A. Hardaway.

CHROMIUM.—Compounds of chromium are constitutionally highly poisonous to the animal system, and chromic acid and its soluble salts are also intensely irritant, and even caustic. Medicinally, preparations of the mineral are used only for local purposes. The United States Pharmacopœial compounds are the following:

Acidum Chromicum, Chromic Acid (chromium trioxide, CrO_3). This compound is in "small, needle-shaped crystals, or rhombic prisms, of a dark purplish-red color and metallic lustre; odorless; destructive to animal and vegetable tissues; deliquescent in moist air. Very soluble in water, forming an orange-red solution. When brought in contact with alcohol, ether, glycerin, and other organic solvents, decomposition takes place, sometimes with dangerous violence" (U. S. P.). On heating, chromic acid first fuses to a reddish-brown liquid, and then decomposes into green chromic oxide and free oxygen. From its powerful chemical action, chromic acid should be kept in glass-stoppered bottles and never brought into contact with any kind of oxidizable organic matter. In concentrated application chromic acid is a powerful and penetrating caustic, and is available in surgery when a deep and thorough cauterization is demanded. But it should not be applied over an extensive area, lest enough be absorbed to produce constitutional poisoning. It is generally used by mixing the crystals with a drop of water to the forming of a paste. The acid is also a powerful oxidizer and antiseptic, thus proving disinfectant, both by destroying low forms of living things, and also by oxidizing foul products of zymotic processes. But its corrosive properties make the disinfectant virtues generally unavailable. Chromic acid is of use, however, for the preservation of organic tissues in the laboratory, particularly nerve structures intended for microscopical examination, since it both preserves and somewhat hardens the specimen while changing but little its histological appearance. It is used for such purpose in very weak aqueous solution. Chromic acid should not be prescribed for internal medication, and, in prescription for any purpose, the explosiveness of its mixture with glycerin and other oxidizable matters must carefully be borne in mind.

Potassii Bichromas, Potassium Bichromate ($K_2Cr_2O_7$). This well-known salt is in "large, orange-red, transparent, triclinic prisms or four-sided tables, odorless, and having a bitter, metallic taste. Permanent in the air. Soluble in ten parts of water at 15° C. (59° F.), and in 1.5 parts of boiling water, insoluble in alcohol" (U. S. P.). On heating, the salt first fuses to a dark-brown liquid, and then decomposes into neutral potassium chromate and green chromic oxide, with evolution of free oxygen. Potassium bichromate is severely irritant and poisonous, and is not used in medicine. In weak aqueous solution it is a convenient preservative for histological specimens, producing effects similar to those of chromic acid. *Mueller's fluid* is compounded of from two to two and a half parts of potassium bichromate and one part of sodium sulphate, dissolved in one hundred parts of water. Potassium bichromate is official in the Pharmacopœia for use, in solution, as a chemical test.

Edward Curtis.

CHROMIUM, POISONING BY.—All soluble compounds of chromium are poisonous. The compounds of most toxicological interest are the trioxide, commonly called chromic acid, CrO_3, the dichromates such as the sodium and the potassium dichromate, $K_2Cr_2O_7$, and the neutral chromates, potassium chromate, K_2CrO_4, and lead chromate, $PbCrO_4$. Potassium dichromate, or bichromate, is the common red salt of commerce, and has caused more fatal cases of chromium poisoning than any of the other compounds of this metal. Chrome yellow, normal lead chromate, and chrome red, a basic salt, are capable of causing chromium poisoning if ingested in sufficient quantity at one time, but when taken in small quantities through long periods of time the symptoms are those of chronic lead poisoning. The salts of chromium, such as chrome alum, $KCr(SO_4)_2$, are not known to have produced poisoning in man. The form of poisoning due to the local action of the dust of the chromates is not uncommon in factories where these chemicals are used, but cases of acute poisoning are unfrequent, though a considerable total number has been reported. The cases have been largely accidental, though there have been some suicides, and in some the dichromate has been taken as an abortifacient.

Uses of Chromium Compounds.—Chromic acid is used in medicine as an escharotic, and in the manufacture of organic chemicals as an oxidizing agent. The alkaline chromates, especially potassium dichromate, are used extensively in dyeing, calico-printing, and tanning, in certain photographic reproduction processes, and in the preparation of other chromium compounds, especially certain pigments, as chrome yellow. The lead chromates are much used in painting, and have been employed for coloring confectionery, and by bakers for giving a yellow color to cakes, etc.

Action of Chromic Acid and the Chromates.—*Local Action.*—Chromic acid is an active oxidizing agent, and when concentrated readily destroys tissues with which it comes in contact. It is hence used as an escharotic in the form of crystals and in strong aqueous solution. In strong solutions it acts on the sound epidermis slowly, but on long contact it penetrates the skin and may be absorbed in this way in sufficient amounts to give rise to constitutional effects. It acts violently on mucous membranes and wounded surfaces, from both of which it is readily absorbed. Fatal acute poisoning has followed its external use, as, for example, in a case in which the solid acid was applied to a carcinoma of the breast and death followed in a few hours with symptoms of chromium poisoning. The alkaline chromates, and especially the dichromates, have a caustic action similar to that of the acid but are much less active. Employees exposed to the dust of these compounds in factories suffer from their caustic action in two ways: through its action on the mucous membranes of the nose, mouth, and eyes, and upon the skin on various parts of the body. The effect of the dust is seen soon after exposure begins, sometimes on the first day. The first symptoms are those of a coryza, becoming more severe with the increasing irritation until there is established obstinate ulceration which ends in the perforation and destruction of the septum narium. At the same time there may develop severe inflammation of the eyelids, and in the mouth and throat ulcers closely resembling those due to syphilis. The dust attacks the site of any injury to the skin with the result that there are formed obstinate circumscribed ulcers which penetrate deeply, going to the bone and even into it. These ulcers may be developed on any part of the body, even those parts covered by the clothing, and have been especially observed about the genitals. As the result of long exposure and irritation the external skin may show chronic skin disorders of the nature of eczema, psoriasis, etc.

Acute Poisoning.—The alkaline chromates are readily absorbed after ingestion, and produce symptoms which, together with those due to the local action in the stomach and intestines, give a marked type of acute poisoning. The salts have a metallic, bitter taste. The symptoms produced by them are, first, those of a severe gastroenteritis; nausea, vomiting of yellow colored material which may be bloody; diarrhœa, and even bloody movements; thirst; abdominal pain; colic; tenesmus; cramps in the legs; great anxiety and prostration; cold and clammy skin; rapid and feeble pulse. These symptoms are followed by pain in the region of the kidneys accompanied by the passage of albuminous bloody urine containing renal tube casts, and even by suppression of the urine. The respiration becomes feeble and irregular, the patient loses consciousness and dies in coma or convulsions. If the fatal result is delayed beyond the first day, jaundice appears as a result of fatty degeneration of the liver. In some cases the gastro-intestinal symptoms are not as prominent as in the typical case, and they may be wanting. If the case be prolonged the symptoms referable to the kidneys and bladder, and to the liver, become more prominent. Death has commonly resulted in from four to fourteen hours (Falk), but has been delayed to fifty-four hours.

Post-Mortem Appearances.—The signs of inflammatory action are usually found in the alimentary tract, though they may be absent. These signs have been observed in all portions of the tract and have indicated all grades of intensity of action: hyperæmia, swelling, ecchymoses, brownish injection of the mucous membrane; corrosion and ulceration. Signs of inflammatory action have also been found in the bladder, the lungs, the endocardium, and the pericardium. The kidneys have been reported as hyperæmic and as showing structural changes in the epithelium of the tubules with abundant cast formation. Fatty degeneration has been observed in the liver and heart muscle, and the blood has been found viscid and very dark. The dark appearance is said to be due to the presence of methæmoglobin (Priestley). The gums may show a bluish-gray line about the teeth which is ascribed to the reduction of chromic acid to chromic oxide, Cr_2O_3.

Fatal Dose.—The amount of alkaline chromates required to produce death is not accurately known, but small doses of potassium dichromate (.03–.20 gm.) may produce distressing symptoms, and under favorable conditions a few centigrams (0.2—0.5 gm.) may produce threatening symptoms. Falk mentions four cases of recovery after doses varying from 0.25 to 4 gm., and recovery has followed doses up to two ounces in cases properly treated. The smallest dose known to have been fatal to an adult appears to have been that in Mr. Wood's case, in which 7.7 gm. (ʒ ij.) caused the death of a woman in four hours (Taylor). Rabbits and dogs are killed by doses of 0.06–0.36 gm. of dichromate, and rabbits from subcutaneous doses of 0.26 gm. of the neutral chromate (Gergens). Considering these data and the effects seen after doses of a few centigrams in man, it is probable that the minimum fatal dose for man is considerably smaller than the one thus far observed, 7.7 gm.

Treatment.—The first indication in acute poisoning is the neutralization and removal of the poison. The acid salt may be converted into the less irritating neutral chromate by the administration of magnesia or sodium bicarbonate. Lead acetate has been recommended with the view of forming the difficultly soluble lead chromate, but it should obviously be used with caution. More important than these chemical antidotes is prompt removal of the contents of the stomach by the use of emetics if there be little vomiting, but better by very thorough washing with the stomach pump. The subsequent treatment of the gastro-enteritis is that of metallic poisons in general, though subnitrate of bismuth would seem to be specially indicated because of the nearly insoluble bismuth chromate that would be formed with the traces of poison remaining.

Experiments on Animals.—The highly poisonous character of chromic acid and its soluble salts has been abundantly shown by experiments. The symptoms and post-mortem appearances seen in the lower animals have been similar to those described as occurring in man, and are referable especially to the irritant action of the poison on the alimentary tract and on the kidney. The structural changes in the kidney have been uniformly found on microscopic examination, even when not obvious from their macroscopic appearances. In long-continued cases typical appearances of contracted kidney have been observed, and several authors indicate this condition as one of the most likely sequelæ to poisoning by chromates. According to Priestley the vaso-motor centres are first stimulated and then paralyzed, and general paralysis precedes the convulsions. The elimination of chromic acid takes place chiefly by way of the urine, but in part also in the fæces. It is found in the mucous membrane of the intestines, and in fæces, even after subcutaneous injection (August Mayer). The elimination is rapid, so that within eight hours sixty per cent. has been removed, and at the end of four days only traces of chromium are to be found in the urine and fæces (Viron).

Chronic Poisoning.—The form of poisoning seen in workers in factories, and due to local action of the dust or strong solutions of the chromate, may properly be considered as a chronic poisoning, but the marked structural changes seen in acute poisoning suggest the inquiry whether there is also a chronic general poisoning due to the absorption of small amounts of chromate. There has been abundant opportunity for the occurrence of cases of such poisoning among employees in factories where chromates are largely used, and also as the result of the therapeutic use of potassium dichromate, in the form of Güntz' solution, in syphilis. It appears, however, that no chronic condition ascribable to this cause has as yet been observed in man. It is possible that the rapid elimination of the chromate is a sufficient protection in the case of man against the effects of small doses, but as a chronic intoxication has been produced in dogs by very long-continued action of chromates (Viron), the possibility of its occurrence in man should be recognized.

Compounds of Chromium.—There appear to be no recorded cases of poisoning in man by salts of the metal chromium, but experiments on animals indicate that they are capable of producing the same lesions as the chromates, but that the dose required is very much greater, and that even with moderately large doses the action is much slower. Pander found that using chromium sodium lactate hypodermically, the lethal dose for warm-blooded animals is about one hundred times that of the dichromate. The elimination is also very rapid. These observations indicate that very large doses indeed would be required to produce serious effects on man.

Herbert E. Smith.

CHROMOSOME.—(χρῶμα, χρώματος, color, and σῶμα, a body.) The substances forming the nucleus of a cell may be roughly divided into two groups. One of these is distinguished by the ease with which the material may be colored with the basic aniline dyes, while the other, like most cytoplasmic structures, is not readily stained with these dyes. The former is called *chromatin*, the latter *achromatin*. During the stages preparatory to the mitotic division of the nucleus the chromatin becomes segregated into a definite number of equal portions. The bodies thus formed are the *chromosomes.*

The difference in staining reactions that the chromosomes exhibit when compared with most of the other structures in the cell indicates a difference in chemical or physical condition. If a quantity of yeast, pus cells, nucleated red blood corpuscles, or other ordinary cells be subjected to artificial digestion with pepsin and hydrochloric acid, the albumens are dissolved and may be removed, leaving a residue which is more or less soluble in weak alkalies and may be precipitated by hydrochloric acid. After being purified this residue is found to be a colorless, amorphous substance insoluble in alcohol and ether, and insoluble or very slightly soluble in water, pepsin and hydrochloric acid, or in weak mineral acids. Microscopical examination of the undissolved residue shows that it consists chiefly of nuclear material, and the chemical substance which is isolated after purification has accordingly been named by Miescher *nuclein.* True nuclein is further characterized by its property of giving off xanthin bodies when boiled with dilute acids; and when treated with an alkali it is split into two substances, an albumin and *nucleinic acid*, as was shown by Altmann. Nucleinic acid, like nuclein, is rich in phosphorus, and Miescher gives as the formula for nuclein obtained from salmon sperm $C_{40}H_{54}N_{14}P_4O_{27}$. But there are undoubtedly several varieties of nucleinic acid, so it is impossible to give a general formula for the series. Both nuclein and nucleinic acid are stained readily with the basic aniline dyes. While similarity of staining reaction does not necessarily indicate similarity of chemical composition, and the reaction of parts of a cell depends largely upon its previous treatment, the evidence as a whole goes to show that the chief chemical substance by which the chromosomes are distinguished from other structures in the cell is nucleinic acid.

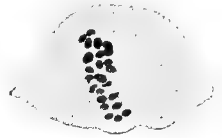

Fig. 1319.—Spermatogonium of the Earthworm (Lumbricus), Showing the Mitotic Figure in the Late Prophase. Twenty-four of the thirty-two small chromosomes may be seen gathered at the equator of the spindle. × about 1,600. (After Calkins.)

In form and structure the chromosomes differ greatly in different organisms, in different cells, and in different stages of development of the same organism. They vary in form from minute globular or elliptical bodies (Fig. 1319) to elongated rods, often bent or twisted, and frequently in a V- or U-shape (Figs. 1322 and 1323). In the process of maturation of the germ cells of both animals and plants the chromosomes appear in the form of tetrads, practically four chromosomes more or less joined together. During the formation of the tetrads the chromosomes often assume the form of rings or crosses, and both of these forms may appear with others in the same cell, as Calkins found to be the case in certain ferns. (See article *Reduction Division*, also articles *Ovum* and *Spermatozoa.*)

Many observers have noticed that, when highly magnified, in numerous cases the chromosomes may be seen not to be homogeneous, but to be composed of smaller units, minute granules of chromatin. In a recent paper on the spermatogenesis of a Pacific coast salamander, Batrachoseps, Gustav Eisen (1900) describes the chromosomes as being composed of a homogeneous chromoplasm containing a definite number of minute bodies, which he calls *chromioles* (Fig. 1322) and believes to be fundamental elements of the nucleus. These are arranged in two rows, one on each side of the chromosome. The latter is constricted slightly at regular intervals, and is thus divided into segments, or chromomeres (Fig. 1321). In the fully developed chromosome of this species there are six chromomeres, each containing six chromioles.

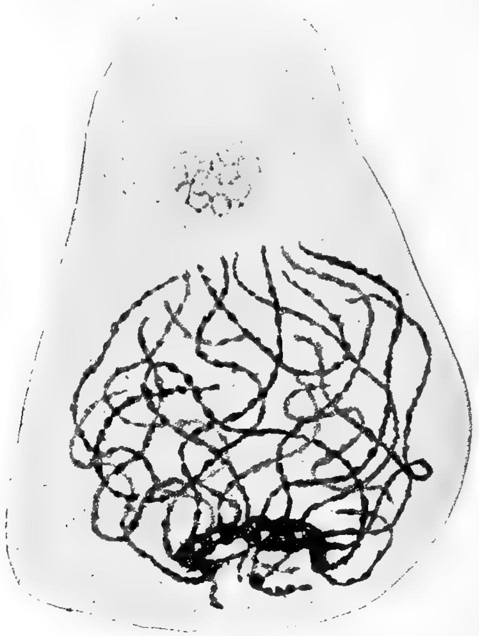

Fig. 1320.—Auxocyte (Primary Spermatocyte) of Batrachoseps. Nucleus in the spireme stage. One or two large chromoplasts are seen in the lower part of the nucleus. × about 1,500. (After Eisen.)

Chromosomes, as a rule, appear only during cell division and their origin and fate are intimately associated with that process, for a description of which the reader should consult the article on *Cell.* Here we are concerned only with the important part played by the chromosomes. In the so-called resting, or vegetative, stage, the chromatic material is generally scattered throughout the nucleus in the form of fine granules, although more or less of it may be gathered together forming "net-knots," or "chromatin-nucleoli." According to Eisen the granules are chromioles. To the chromatin-nucleoli he gives the name of *chromoplasts*, and believes them to be of equally fundamental importance with the chromioles. Preparatory to division, the chromatin becomes united into one or more slender threads coiled within the nuclear membrane and forming the *spireme* (Fig. 1320). Next the spireme thread shortens and thickens, and finally it is divided by transverse fission into a number of separate segments: these are the chromosomes. According to Eisen, in the cells of the testes of Batrachoseps the chromoplasts are the centres of activity in the formation of the spireme. The chromioles become arranged in rows and connected by an enveloping chromoplasm, forming slender threads, or "leaders," and this takes place in connection with the chromoplasts, each one having several leaders radiating from it (Fig. 1320). The usual shortening and thickening of the leaders takes place, and they become reduced in number until, in somatic mitoses, there are twenty-four. Finally, the chromoplasts divide so that there are formed twenty-four separate chromosomes, each one provided with a chromoplast at one end.

In the mean time the achromatin spindle has been formed, and the nuclear wall has faded away leaving the chromosomes lying free in the cytoplasm. The chromosomes now migrate toward the equator of the spindle until they become arranged in a circle around it (Fig. 1321). Then follows the most important and essential operation in the division of the nucleus, the separation of each chromosome into two exactly equal halves (Fig. 1322). This is preceded by a *longitudinal* fission, which takes place in some species at this stage, in others at various earlier stages as far back as the spireme. The separation having been accomplished, one-half of each chromosome moves to one pole of the spindle, the other to the other pole; so that in the anaphase there are collected at each pole of the spindle the same number of chromosomes that were formed in the mother-nucleus (Fig. 1323). Each of these groups of chromosomes then forms a new daughter-nucleus. This may take place in one of two ways: either the chromosomes may unite to form a spireme thread, after which the chromatin becomes more diffused and a nucleus membrane is formed around the whole; or else each chromosome may swell and form a vesicle, and the vesicles then fuse to form the new nucleus. When, after a resting stage, the nucleus again prepares for division, the chromosomes which reappear within it are of the same number as those of which it was originally formed.

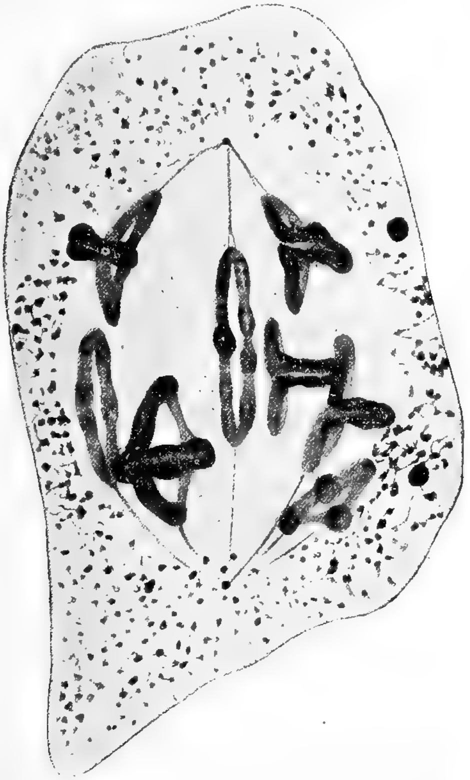

FIG. 1321.—Auxocyte of Batrachoseps in a Stage Immediately Preceding the Metaphase. Eight of the twelve chromosomes are seen approaching the equator of the spindle. × about 1,500. (After Eisen.)

It is now established as highly probable, that every species of animal and plants has a constant and characteristic number of chromosomes, which appears at each successive division of the somatic cells. Wilson gives a list of seventy-two species in which the number has been determined. Thus, in the worm Ophryotrocha, there are four; in Nais, Spirogyra, Limax, Pinus, and Allium there are sixteen, and man has been supposed to have this same number; eighteen are found in the sea urchin, Echinus, and in Ascidia; the salmon, frog, mouse, and lily have twenty-four; thirty-six have been found in Torpedo and certain sharks; and the crustacean, Artemia, is said to have one hundred and sixty-eight. It will be noticed that in each of these cases the number is an even one; and in each of these cases and the others mentioned in Wilson's table the nuclei of the mature male and female germ cells have been found to contain exactly half as many chromosomes as the somatic cells.

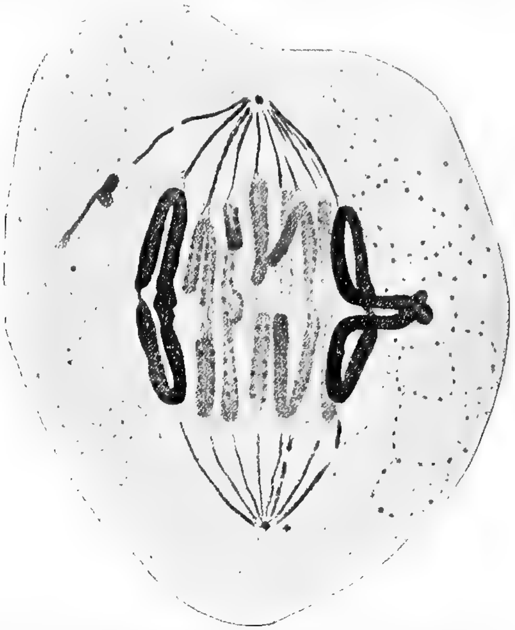

FIG. 1322.—Auxocyte of Batrachoseps in the Metaphase, Chromosomes Dividing. × about 1,500. (After Eisen.)

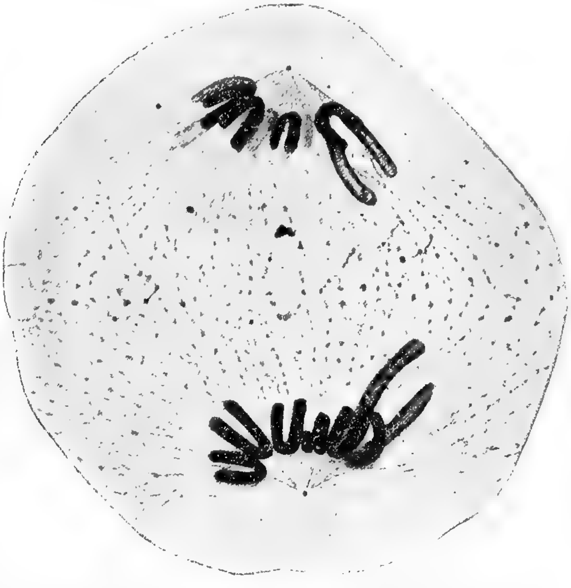

FIG. 1323.—Auxocyte of Batrachoseps in the Late Anaphase, Daughter-Chromosomes Collecting at the Poles of the Spindle. × about 1,500. (After Eisen.)

In the ferns and their allies there is an alternation of generations. A prothallium derived from a non-sexual spore produces male and female germ cells. These give rise to the fern plant, which in turn produces non-sexual spores. In several of the ferns and Hepaticæ it has been found that the reduction in the number of chromosomes does not take place, as in animals, in the formation of the germ cells; but it occurs during the development of the spores, and all the cells of the prothallium, both somatic and germ cells, have half the number of chromosomes found in the somatic cells of the fern plants. (See *Reduction Division.*)

That interesting parasite, *Ascaris megalocephala*, presents a curious exception to the law of the number of chromosomes. The mature germ cells of this species have only one chromosome (var. *univalens*), or two (var. *bivalens*), and the first blastomeres in the dividing ovum have correspondingly two or four chromosomes. This is true also of the cells which in later stages are destined to form the germ cells for the next generation. But in the subsequent divisions of the purely somatic cells the chromatin becomes divided into a large number of very minute chromosomes; it is probable, however, that the number is constant.

Only in rare instances do the chromosomes persist intact from one cell-division to the next. Still there are a number of facts which seem to indicate that the chromosomes which appear preparatory to the division of a nucleus are individually the same as those which formed that nucleus after the previous division.

The evidence for this view may be considered under three heads: 1. The correspondence between the number of chromosomes entering into the formation of a nucleus and the number issuing from it. 2. The correspondence in position between the place of disappearance of the chromosomes and the place where they reappear. 3. The observed distinctness of the groups of chromosomes derived from the male and female parent respectively.

The law that "whatever be the number of chromosomes entering into the formation of a reticular nucleus, the same number afterward issues from it," has been found to hold good in all normal cell-divisions that have been observed, except in the special cases of the spermatocyte and oöcyte in animals and the corresponding spore cells of plants. These special cases, which will be fully considered in the article on *Reduction Division*, do not detract from the force of the evidence furnished by the general rule. The force of this rule is most strikingly illustrated by certain abnormalities, especially in the eggs of Ascaris.

In the commoner variety of *Ascaris megalocephala*, var. *bivalens*, the oöcyte, or immature egg, has the chromatic elements of the nucleus arranged in two groups of fours, tetrads. One tetrad goes into the first polar body; the other divides into two dyads, and one goes into the second polar body and the other dyad forms the two chromosomes of the female pronucleus. Thus we have in the first polar body four chromosomes, two in the second polar body, two in the female pronucleus, and the spermatozoon brings in two more, making a total of ten. The variety *univalens* presents the same phenomena except that the numbers are just one-half of these. Fortunately in these wonderful eggs the polar bodies persist until the formation of the embryo is well under way, and the chromosomes in them may be counted.

Now Boveri and Herla have shown that while development ordinarily follows the normal course, various abnormalities may occur; but, with the exception of two or three possibly doubtful cases, the total number of chromosomes may always be accounted for according to the rule. For example, in var. *bivalens* it sometimes happens that two small female pronuclei are present instead of one large one, and when the chromosomes are formed it is found that only one chromosome appears in each of the small pronuclei, the total number remaining the same. In other eggs four chromosomes were found in the female pronucleus or six in the first cleavage spindle, but the second polar body was not to be found and had evidently not been extruded. Again, cases were found in which there were only three chromosomes in the first polar body, and the missing one was discovered in the second maturation spindle or in the female pronucleus.

Herla, however, found one female in which all the eggs showed the normal polar bodies of var. *bivalens*, but in the first cleavage spindle and subsequent stages there were only three chromosomes. But in the same intestine he found other worms of the var. *univalens*. There is strong reason to believe that this was a case of crossing, the female of one variety having been impregnated by the male of the other, and thus the rule would still hold good. In other worms from the same source a few cases were found of redundancy of chromosomes with normal polar bodies. Herla explains these as due to the entrance of two spermatozoa, which Van Beneden has shown to occur rarely. In short, all the abnormalities are susceptible of explanation in accordance with the rule, there being only two or three very rare cases in which the validity of the explanation might be questioned.

The rule is further confirmed by observations of Brauer on the parthenogenetic eggs of the crustacean Artemia, and Boveri and Morgan have made the interesting discovery that it is possible to fertilize fragments of echinoderm eggs which contain no female pronucleus and to obtain larvæ whose cells contain just half the normal number of chromosomes, the number introduced by the spermatozoon. Very recently E. B. Wilson has found that the same is true of echinoderm embryos derived from eggs which have been stimulated to develop by Loeb's chemical method without the entrance of a spermatozoon.

In all these cases, wherever the number of chromosomes in the first cleavage spindle has been altered as the result of some accident of maturation or fertilization, this same number is found to reappear in subsequent stages. Thus these abnormalities contribute striking proof of the law of equality in the number of chromosomes.

While it is true that if the chromosomes maintain their individuality in the reticular nucleus, the same number must appear at the close of the resting period as were present at the beginning, the demonstration that this is the fact does not prove that the new chromosomes contain the same elements. There may be an entire rearrangement of the chromatin during the reticular stage. Therefore, if it can be shown that, besides being equal in number, the chromosomes are reformed in the same part of the reticulum where they disappeared, we shall have greatly strengthened the evidence for their individuality.

So far the only form that has supplied such evidence is Ascaris. Here in the two-cell stage when the chromosomes unite to become the nucleus, the ends of the chromosomes project from the general mass and persist during the resting stage as reticular lobes, and the first step in preparation for the second division is the concentration of the chromatin in these same lobes to form the ends of the new chromosomes. The ends of the chromosomes in this case, therefore, appear to be composed of the same chromatin before and after the resting stage. As to whether this is true of the middle part or not the evidence is inconclusive.

Finally there is a certain amount of evidence, that if not the chromosomes, at any rate the mass of chromatin derived from each parent, remains distinct. In the hybrid eggs of Ascaris, Herla found that the female pronucleus gave rise to a single thread of chromatin which divided transversely to form the two chromosomes, while the male pronucleus produced a much shorter thread that did not divide. In subsequent divisions of the series leading to the formation of the primordial germ cells of the embryo he observed that the three chromosomes arose in the same way, indicating a persistent distinction between the chromatin of maternal and that of paternal origin.

In a little copepod, *Cyclops strenuus*, Häcker and Rückert have demonstrated that the twelve chromosomes of each germ-nucleus remain distinct and give rise in the two-cell stage to a distinct half of the bilobed nucleus of each cell. Two spiremes are formed in the next stage, producing separate groups of twelve chromosomes, and Rückert traced the maternal and paternal groups of chromosomes in this way through several successive cell-divisions and found evidence of the dual nature of the nuclei as late as the stage of the formation of germ-layers.

In conclusion it may be said that while it is not possible at present to give a rigorous proof of the individuality of the chromosomes, the three lines of evidence just reviewed give to the hypothesis a considerable degree of probability.

The physiology of the chromosomes is the most difficult question that we have to consider, because experiment is wellnigh impossible, and we can draw inferences as to their functions only from the appearances observed in the various stages of cell activity.

There are a number of observations and experiments, however, to show that the nucleus plays a very important part in the economy of the cell. Thus, if the body of a unicellular organism be divided so that one part contains no nuclear material, this part may remain alive for some time but is unable to digest food or to repair the damage, while the part containing the nucleus can do all of this and soon becomes as perfect as before.

That the chromatin is the most essential part of the nucleus seems to be evident from the phenomena of mitosis. Here we see every part of the mechanism designed apparently to effect the exactly equal distribution of the material to the two daughter-cells; and when the daughter nuclei are re-formed they are produced entirely by the transformation of the chromosomes. Rückert has found that in a shark, Pristiurus, the chromosomes persist during the growth period of the egg. At first they are small and stain darkly. During the growth of the egg they increase enormously in size and lose in staining capacity, and at the end of the period they contract to one-sixth of their original length and stain very darkly. "As Rückert points out, the great increase of surface in the chromosomes is adapted to facilitate an exchange of material between the chromatin and the surrounding substance; and he concludes that the coincidence between the growth of the chromosomes and that of the egg points to an intimate connection between the nuclear activity and the formative energy of the cytoplasm." "We may infer that the original chromosomes contain a high percentage of nucleinic acid; that their growth and loss of staining power is due to a combination with a large amount of albuminous substance to form a lower member of the nuclein series, probably a nucleo-proteid; that their final diminution in size and resumption of staining power is caused by a giving up of the albumen constituent, restoring the nuclein to its original state as a preparation for division." Ordinarily these chemical changes and interchanges between chromatin and achromatin take place in the reticular stage of the nucleus, and the chromosomes, as they are usually observed, probably have nothing to do with them. The reticular nucleus is probably not at all in a "resting stage" but is a seat of lively metabolic activity, and it is more probable that the chromatin of the chromosomes is in more nearly an inactive condition. Why the chromatin should assume this form at the time of division is not known, but the presence of the chromosomes at almost every cell-division in the whole range of forms from the protozoa to man and the higher plants indicates that their formation is an essential step in the process.

The most important function that has been ascribed to the chromosomes is that of transmitting the physical basis of heredity from one generation to the next. Statistical studies of Galton, Pearson, and others indicate that on the whole the heritages from the two parents to the offspring are equal. There must be in the fertilized egg, then, some material body derived in equal proportion from the two parents, and the chromosomes are the only bodies that so far have been found to meet this requirement. Moreover, during the first cleavage of the egg each chromosome is divided by longitudinal fission into exactly equal parts, which are distributed to the two daughter-cells so that each one has an exactly equal number of chromosomes of paternal and of maternal origin. If the individuality of the chromosomes be a fact, then this equal distribution of chromatin from the two sources is extended to all the cells of the body. If we further assume as proven that the chromatin is the seat of the formative activity of the cell, then we begin to gain some insight, apparently, into the manner in which the maternal and paternal characteristics are commingled in all parts of the offspring.

It may be asked, and with good reason, How is it possible for the complex of hereditary qualities of a gifted father to be transmitted to his distinguished son through a few ultra-microscopic threads of nucleinic acid? The theories of heredity will be discussed in another article (see *Heredity*), but it may be pointed out here that nuclein and nucleinic acid are the products of dead nuclei. We have no knowledge of the chemical substances in the living nucleus and chromosomes beyond the fact that they are so combined that when their vital activities have ceased they yield to the chemist bodies of the nuclein series. The nucleins are certainly very complex bodies, but there can be little doubt that the living chromosomes are infinitely more complex than anything we can discover with the microscope or by chemical analysis.

Robert Payne Bigelow.

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CHRYSAROBIN.—CHRYSAROBINUM, U. S. P. A neutral principle, in its commercial, more or less impure form, extracted from Goa powder, a substance found deposited in the heart wood of *Vouacapoua Araroba* (Aguaiar) Lyons (fam. *Leguminosæ*). This, sometimes misnamed chrysophanic acid, is the crystalline substance of which "Goa powder" principally consists. It has long been used in Brazil, whence its employment has spread through Portuguese commerce to India and the East. Its general European and American employment is comparatively recent. Goa, or Araroba, is a pulverulent substance, contained in long and large canals in the older wood of the trunks, and also in large irregular cavities in the same, formed by erosion or degeneration of the wood itself. It is obtained by cutting and splitting up the trees, and scooping or scraping out these canals and cavities. It is considerably irritating to the skin and mucous membranes, and severe inflammation of the face and eyes of those who collect it is not unusual. Lachrymation and sneezing are readily produced by sifting or handling the powder. Crude Goa is a coarseish powder, mixed with lumps and fine bits and fibres of wood, varying from dull yellow (when fresh) to reddish brown, or even a greenish or violet-brown color, with the other properties of its purified product as described below. Besides small amounts of sugar, gum resin, and cellular tissue, it contains, as was first shown by Professor Attfield, eighty-five per cent. of a yellow crystalline substance, which he supposed was *chrysophanic acid*, but which Lieberman afterward proved to be a mixture consisting mostly of a peculiar substance, *chrysarobin*, having many points of resemblance to the above-mentioned acid, containing a little of it, and, in fact, capable of being transformed into it by oxidation. The impure chrysarobin of the Pharmacopœia is thus described: "A pale, orange-yellow, microcrystalline powder, odorless and tasteless, turning brownish yellow on exposure to air. Very slightly soluble in cold water or alcohol; soluble, without leaving more than a small residue, in 150 parts of boiling alcohol; also soluble in 33 parts of boiling benzol, and in solutions of the alkalies."

Chrysarobin taken internally is an active irritant to the alimentary canal, causing violent and persistent catharsis and vomiting. It is eliminated, partly unchanged and partly converted into chrysophanic acid, by the kidneys, which glands are extremely irritated by it, and hæmaturia and interstitial nephritis may follow. It is, however, here never given internally, its use being confined to local applications as an irritant and parasiticide in chronic psoriasis, pityriasis versicolor, and tinea tonsurans. It produces an active acute inflammation, which as it subsides leaves the original malady in an improved condition. Chrysarobin stains both skin and clothing badly. The ointment (*Unguentum Chrysarobin*, U. S. P., strength five per cent.) is of a suitable strength for inunction.

W. P. Bolles.

CHRYSOIDIN. — $C_6H_5N,NC_6H_3(NH_2)_2HCl$—Diamidoazo-benzol hydrochloride. This is a red-brown crystalline powder soluble in water and used in solution as an antiseptic mouth wash. *W. A. Bastedo.*

CHRYSOPHANIC ACID.—*Rheic Acid. Rhein.* $C_{14}H_5(CH_3)(OH)_2O_2$. This is a bright yellow crystalline powder extracted from rhubarb, to which it imparts the yellow color. It is insoluble in water and only slightly soluble in alcohol, but dissolves in both ether and chloroform. It is highly irritant, and has the same properties and uses as *Chrysarobin*, which see. *H. H. Rusby.*

CHUCANDIRO.—Michoacan, Mexico. These waters enjoy a great reputation in the country because of their warmth (which is that of the normal human body), their clearness, and their curative properties. They contain a high percentage of hydrochloric acid in solution.

N. J. Ponce de Léon.

CHYLANGIOMA. See *Angioma.*

CHYLE.—The term chyle is applied to the milk-white, opaque fluid which fills the lacteals, or lymphatic ducts, of the small intestine during the digestion of food containing fat. Since the fluid from the lacteals preponderates in that of the thoracic duct and causes the latter to assume a similar appearance, the term chyle is also frequently applied to the contents of the thoracic duct during the absorption of fats. The physical and chemical properties of this fluid vary at different times and under various circumstances; the most important factor determining its properties is, however, the character of the food in the intestinal canal. In a starving animal or in one which has received only fat-free food, the liquid of the lacteals is not to be distinguished either in appearance or in chemical composition from ordinary lymph.

Much of our knowledge of the character and composition of chyle has been derived from experiments upon the lower animals, and especially from experiments upon the dog. In this animal it is not difficult to insert a cannula into the thoracic duct where it joins the left subclavian vein at the root of the neck; in this manner the chyle may be collected for any desired period and the factors affecting the composition and rate of flow studied. Unfortunately, the fluid collected in this manner is not pure chyle, but consists of a mixture of chyle and of lymph coming from the lymphatics of the liver, kidneys, pelvis, abdominal walls, lower extremities, etc. In large herbivorous animals cannulæ have been inserted into the lacteals directly and pure chyle obtained. The chyle of man has seldom been studied; in rare cases fistulæ connecting with the lacteals or with the thoracic duct have been described and the fluid escaping therefrom examined. Cases are also reported in which the thoracic duct became occluded and ruptured, allowing the chyle to escape into the pleural or peritoneal cavity, from which it was removed by puncture.

Chyle obtained by one of the above methods is, when a mixed diet has been given, a white, opaque fluid; occasionally it is colored slightly red or yellow from the accidental presence of red blood corpuscles. In herbivora it may have a greenish tinge from chlorophyl derived from the food. It has an alkaline reaction due to carbonates and phosphates of sodium. The specific gravity is 1.018 to 1.025. It has a salty taste and the odor (due to volatile fatty acids) peculiar to the animal from which it is derived. It coagulates upon standing, sometimes more, sometimes less, readily. Examined microscopically chyle is found to contain two kinds of formed elements, leucocytes and fat granules. The leucocytes have their origin chiefly in the lymphoid tissue of the intestinal tract and the lymph glands of the mesentery; chyle obtained from the lacteals before they pass through lymph glands is found to contain fewer leucocytes than that from vessels which have passed through these glands. A constant stream of leucocytes thus passes from the chyle into the blood; this forms an important source of the white corpuscles of the latter. The fat, which exists in a state of the finest division, will be discussed below.

Since chyle is but a form of lymph we should expect to find a close resemblance between the chemical composition of these two fluids; the following table from Munk, giving the results of analyses of chyle and of lymph of man, shows that this is the case.

One hundred parts.	Chyle.	Lymph.
Water	92.2	95.2
Solids	7.8	4.8
Fibrin	.1	.1
Proteids	3.2	3.5
Fats (lecithin and cholesterin)	3.3	Traces.
Extractives	.4	.4
Salts	.8	.8

This table shows very clearly that chyle differs from ordinary lymph in but one important point, viz., in containing a larger percentage of fat. In exceptional cases chyle contains a larger percentage of sugar than does lymph; this point will be discussed below. Since chyle, like lymph, is derived from the blood, it is of interest to compare the composition of the blood serum and the chyle of the same animal. The following table is from analyses made by Hoppe-Seyler; the fluids were obtained from a dog.

	Chyle.	Serum.
Water	90.67	93.60
Fibrin	.11	....
Albumin and globulin	2.10	4.52
Fat (lechithin and cholesterin)	6.48	.68
Other organic substances	.23	.29
Salts	.79	.87

These analyses show that chyle differs from serum in two important particulars: it contains a larger percentage of fats and a smaller percentage of proteids. Lymph similarly contains a smaller percentage of proteids than does blood serum. The amount of urea in the chyle is, according to Grehant and Quinquaud, greater than that in the blood; they found from 46 to 95.5 mgm. of urea in 100 gm. of chyle, and only about one-half as much in blood.

The salt occurring in the greatest abundance in chyle is sodium chloride (.58 per cent.); then come sodium carbonate (.15–.22 per cent.) and the phosphates of the alkalies and alkaline earths (.04 per cent.). Other salts, as potassium iodide and potassium ferrocyanide, are occasionally found in the chyle as abnormal constituents. At times a small amount of lactic acid is present.

The proteids of the chyle are serum albumin and serum globulin: the former is two and a half to four times as abundant as the latter. Cholesterin and lecithin are constant constituents of the chyle: in analyses they are frequently reckoned with the fats in the "ethereal extract."

Some analyses showed from 18 to 102 mgm. of cholesterin per 100 gm. of chyle; lecithin was found in much smaller quantity—only about half as much of this being present, as a rule, as of cholesterin.

It has already been shown that the only important difference between chyle and lymph is the presence in the former of a large amount of fat. If the contents of the lacteals be examined in an animal which has received no food for many hours or only fat-free food, this difference does not obtain, and the contents of the lacteals cannot be distinguished from ordinary lymph. These considerations suggest that fats are absorbed by the lacteals, and that this is the case has long been known. The question is often raised, Are the lacteals the only path for the absorption of fats? While this question is usually answered in the affirmative, the proofs are by no means complete. The amount of fat absorbed from the intestines is easily determined by weighing the amount of fat fed, and that remaining in the digestive tract after a given period; the difference gives the total amount absorbed. The fat absorbed by the lacteals is determined by collecting the chyle as it flows from the thoracic duct and weighing the fat it contains. When the amount of fat obtained from the thoracic duct is compared with that absorbed from the intestines, a marked deficit is always found; the most careful work has failed to recover more than sixty per cent. in this way. The fate of the rest of the fat is not known; there is, however, no evidence that any of it passes into the portal system.

Fat does not seem to be absorbed by the lymphatics of either the large intestine or the stomach, for the contents of these are always clear; the epithelial cells lining these organs are, however, sometimes found filled with fat droplets, but it is not known what finally becomes of these.

The amount of fat in the chyle varies within wide limits, being determined by the amount and character of the fat of the food. It is said that the chyle of the dog may contain as much as fifteen per cent. of fat; the maximum amount found by Munk in man was about five per cent. The time after a meal at which fat appears in the chyle is very variable, being determined largely by the character of the fat fed. Zawilski (Ludwig's "Arbeiten," ii., 1876, p. 147) introduced into the stomach of a dog 150 gm. of fat (the variety is not stated). Two hours afterward fat was detected in the chyle; the maximum amount was found in the tenth hour, and fat was still present after nearly thirty hours. Munk and Rosenstein (to whom we are indebted for nearly all of our knowledge of the absorption of fat in man) carried out a similar series of experiments on a human being (Virchow's *Archiv*, 123, p. 230). These investigators had the opportunity of observing and experimenting upon a girl who, as a result of elephantiasis of one leg, had a fistula in the thigh which communicated through the left lumbar lymphatic duct with some of the lacteals. It was found that when fat was given to this patient, two-thirds of it could be recovered in the fluid escaping from the fistula in the following twelve hours; further, examination of the blood at the height of digestion showed no more fat to be present than when the patient was fasting. Munk and Rosenstein concluded from these observations that nearly all the chyle escaped through the fistula. A unique opportunity was thus offered to extend to man the experiments which had been made upon animals as to the absorption of fats. Some of the more important results will be given below. In one experiment the patient was given 41 gm. of olive oil; the fluid escaping from the fistula, and which had hitherto been clear, became milky in appearance during the second hour and chemical examination showed the presence of much fat. The maximum amount of fat was found in the fluid escaping during the fifth to the sixth hour; the fluid now contained 4.3 per cent. of fat, and 5.6 gm. passed out during the hour. The percentage of fat in the chyle rapidly decreased from this time on, and from the eleventh to the thirteenth hour only 0.8 gm. was obtained. In all, 60 per cent. of the fat fed escaped from the fistula. When a fat with a high melting point (like mutton fat which is solid at ordinary temperatures) was given, the course of absorption was similar, except that the maximum percentage of fat in the chyle (3.8 per cent.) appeared somewhat later—between the seventh and the eighth hour; that is, the mutton fat was absorbed with more difficulty than was the olive oil. The greatest amount recovered in one hour was 4.7 gm., and of the entire amount 55 per cent. was obtained from the chyle. When cream was given to the patient, as much as 11.2 gm. of fat was obtained in one hour.

From earlier experiments on lower animals Munk had found that when fatty acids are fed they appear in the chyle as neutral fats; he was able to confirm this result on the patient in question. For example, when 17 gm. of erucic acid was given, 8 gm. of the corresponding neutral fat (erucin) was obtained from the chyle escaping during the following ten hours; in other words, a union of erucic acid and glycerin (derived from the tissues) had occurred during the course of absorption. Very little free acid was found in the chyle. Munk also tried experiments with spermaceti, a fat which melts at a temperature (127° F.) much above that of the body, and in which the palmitic acid is combined with cetyl alcohol instead of with glycerin as in ordinary fats. In these experiments the fatty acid appeared in the chyle in combination with glycerin: that is, the spermaceti had been decomposed and the palmitic acid had combined with glycerin during the course of absorption. These experiments also show that fats which are solid at the temperature of the body can be absorbed; the earlier view was that such fats escaped absorption altogether. When a fat containing amyl alcohol instead of glycerin was given, the fat of the chyle was a triglyceride, showing again that a decomposition and synthesis had occurred during absorption. In other experiments oil in the form of an emulsion was given by the rectum; four to six per cent of the fat was absorbed and appeared in the chyle in the course of eight or nine hours.

It is held by some that fats are absorbed from the intestines chiefly in the form of soaps; if this is the case they are transformed into neutral fats very soon after absorption, for soaps are present in but very small quantities in the chyle—only to the extent of about 0.2 per cent. In fact the soaps of the alkalies have been shown by Munk to produce poisonous effects similar to those caused by the albumoses when they are injected intravenously. Very little free fatty acid has been found in the chyle, and the amount is not increased by the ingestion of fatty acids.

Thus the fat of the chyle is almost entirely in the form of neutral fats; it is suspended in the liquid as an extremely fine emulsion. The fat granules are less than 1 μ in diameter and show Brownian movements. This emulsion is much finer and more uniform than that which is formed in the intestine; the fat granules in the latter vary in size from 1 to 20 μ or even more. The emulsion of the chyle also differs from ordinary fat emulsions in that it is not destroyed by acids. There is, however, no protecting membrane, as was once thought to be the case; the fat is easily removed by shaking with ether which causes the liquid to become transparent.

Many experiments have been made to determine whether substances other than fats, such as proteids and carbohydrates, pass from the intestinal tract into the chyle. The numerous experiments upon the lower animals and those of Munk and Rosenstein upon man agree in showing that normally fat is the only food-stuff which takes this path. Water and substances easily soluble in water, such as salts, proteids, and sugars, are absorbed by the blood-vessels. When, however, very large amounts of sugar, etc., are fed, some may be absorbed by the lacteals and so appear in the chyle. Munk and Rosenstein, for example, found that after giving 100 gm. of sugar the percentage of sugar in the chyle rose from 0.1 to 0.33 per cent.; only 0.5 per cent. of the total amount absorbed from the intestine was found, however, in the chyle. These authors found no appreciable increase in the amount of proteid in the chyle after feeding 103 gm. of albumin. Asher and Barbèra (*Centralblatt für Physiologie*, xi., p. 403, 1897), on the other hand, found that when a very large amount of proteid (200 gm.) was introduced into a dog's stomach, as much as 6.4 per cent. of it could be recovered from the chyle; such results are not obtained when moderate amounts of proteids are used.

The quantity as well as the character of the chyle varies considerably during the course of a day. It increases during the period of digestion and decreases markedly during fasting. Most of the observations upon this point have been made upon the lower animals. Colin, using figures derived from an experiment in which chyle was collected from one of the large lacteals, calculated that in a young bull weighing 200 kgm. about 15 kgm. of chyle was formed per day. There are no observations which allow of more than an appropriate estimation of the amount of chyle formed in man. Munk and Rosenstein found in the experiments described above that from 70 to 120 gm. of chyle escaped, per hour, from the fistula before, and 150 gm. after a meal. Noel Paton (*Journal of Physiology*, ii., p. 109) observed the flow of lymph from the thoracic duct in a case in which this duct had been injured during an operation for sarcoma of the neck; he estimated the normal amount to be from 130 to 195 c.c. per hour. Of course in both of these cases the liquid was not pure chyle, but was a mixture of chyle and lymph from other sources; in Noel Paton's case, moreover, the patient was in a very abnormal condition.

Chyle, in addition to being the medium of the absorption of fats, is the lymph of the small intestines; it serves the same purpose and is formed in the same way as the lymph of other organs. (See article *Lymph.*)

Reid Hunt.

CHYLOUS AND ADIPOSE ASCITES.—Medical literature of the sixteenth and seventeenth centuries abounds in instances of traumatic lymphorrhagia and lymphorrhœa, especially after venesection.[1] Reviewing the records, we cannot avoid the conclusion that a large number of these cases were of chronic pyogenic or tuberculous infection. Nuck[2] and Practicus[3] have recorded (1695) cases of milky saliva, and Rommel one in which a milk-like fluid exuded from the exterior surface of the abdomen. Milk-like discharges recorded in puerperal women are probably pyæmic processes. Dilated lymph vessels, lymphatic varices, have been observed in serous membranes, the heart, lungs, small intestines, liver, spleen, conjunctiva, and tunica vaginalis.

Kamienski (*Jahrbuch für Kinderheilkunde*, 1896, Bd. xli., p. 429) deals with the relation of lymphangioma in the abdominal lymph vessels to chylous ascites. The causes of lymphatic varices are filaria, adenitis, periorchitis hæmorrhagica, lymphatic obstruction, and perhaps lymphangitis gonorrhœica. Lymphocele is increasing in frequency both in this country and abroad.[4]

Chylopericardium is extremely rare, there being but two cases on record; one case resulted from leakage of chylous fluid from the pleura, and the second instance was due to rupture of chyle vessels. Hasebroeck[5] reports a case in which albumin 7.0, cholesterin 0.3, lecithin 0.1, fat 1.0, alcoholic extractives 0.2, aqueous extractives 0.2, and salts 0.9 per cent., were found.

Chylothorax is more frequent, about forty-five cases being recorded. Some sixteen (Wiescher, "Zur Casuistik der Verletzung des Duct. Thoracicus," *Deut. Zeits. für klin. Chir.*, Bd. xxxviii., H. 4, 5; also contains account of experimental work upon the thoracic duct; Gjorgevic [Langenbeck's *Archiv*, 1870, S. 653]) resulted from direct trauma to the thoracic duct. Rupture of the thoracic duct is uncommon on account of its protected location, and it heals readily on account of low pressure there, although it has been stated that recovery never follows rupture. Other causes of chylothorax are: chylous effusions (Quinke), altered pus (Guéneau de Mussy), and chyliform fluids distinct from serous, purulent, and sero-fibrous effusions (Débove).

Effusions into the thoracic cavities are divided according to Rotmann into chylous and chyliform as follows:

I. CHYLOUS.—RUPTURE OR TRANSUDATION OF CHYLE THROUGH VESSEL WALLS.

External violence	8
Carcinoma of pleura	5
Closure subclavian vein	4
Tumors compressing thoracic duct	2
Malignant lymphoma	2
Ectasia, sclerosis of lymph vessels	2
Stopping thoracic duct	1
Filaria (?)	1
Over-exertion	1
Total	26
Leakage through diaphragmatic lymph vessels from peritoneum	1

II. CHYLIFORM.

A. Fatty cells.	
Carcinoma of pleura	5
Tuberculous pleuritis	3
Non-tuberculous pleuritis	3
Lung abscess (?)	1
B. Lipæmia (Débove) ?	1
Total	13

The most recent cases of chylothorax are those of Simon (*Mitth. Grenzgeb. Med. und Chir.*, Bd. v., H. 2), in which a lymphangioma of the leg reached the thorax and burst into the pleura; Ceconi, Rassius, Hampbell, Corselli, Frisco, Bayer, and Henssen. Bayer has collected twenty cases of combined chylothorax and chylous ascites.

The peritoneal cavity, more frequently than any other serous sac, is the seat of those unusual exudates and transudates known as chylous, chyliform, lactiform, oily, or adipose ascites. The first authentic case is Poncy's (1699), but during the last two centuries the literature, carefully considered, gives 156 cases. Three have fallen under my personal observation.

PATHOGENESIS.—Letulle (*Revue de Méd.*, November, 1885, p. 960) holds that chylous and adipose effusions are always formed by peritonitis, independently of any opening or connection with the lacteal vessels. He espouses the view of Guéneau de Mussy, that products of serous or purulent inflammation are slowly transformed by leucocytes into a granulo-fatty emulsion. All cases, then, of chylous ascites are, according to Letulle, mere instances of chronic tuberculous, cancerous, and neomembranous peritonitis. On comparison of pus, chylous effusions, and ascites, he finds that chylous extravasations and pus are quite similar as regards the percentage of albumin, amount of salts, and total solids, and he concludes that chylous fluids are residual, occupying a position intermediate between ascites and pyo-peritoneum. The amount of fat is not sufficient to cause the opacity, which he refers rather to the regressive process. In one of Méher's cases there was only 0.48 gm. of fat per kilogram, yet the fluid was opaque. Laissaigne (*Journ. de chem. méd.*, 1825, t. i.; cit. Gendrin, "Histoire anat. des inflam.," t. ii., p. 548) and Robin ("Traité des humeurs") claim that fat is present in the fibrin of serous exudations, as in chronic pleuritis. Cullen ("Méd. pratique," edit. 1787, t. ii., p. 580) and Gendrin remarked the lactiform appearance of chronic inflammatory serositis. Broussais ("Hist. des phlegmasies on inflam. chron.," t. iii., ch. iv., Paris, 1831) described a lactiform effusion with thickened peritoneum and De Laharpe (*Archives gén. de méd.*, 1842, t. xiv., p. 358) mentions the occurrence of a milky fluid whose opalescence was due to particles of fat. Méhu (Gjorgevic, Langenbeck's *Archiv*, 1870, p. 653) says that fat and often also cholesterin were found in ovarian cysts, hydrocele of the tunica vaginalis, old cysts, ascites, and very old hæmatoceles. Letulle thinks that this quotation solves the entire problem. Guéneau de Mussy also explains fatty pleurisy by fatty degeneration of endothelial cells (*Clin. méd.*, t. i., p. 658). Veil agrees with Letulle, and Sainton with Débove (Mém. Soc. Méd. des Hôp., 1881, p. 49) claims that ruptures in the chyle system found by others were made by post-mortem violence. The symptoms of chylous effusions are not those of suppurative pleuritis or peritonitis, and he therefore excludes pyogenic processes from the etiology. These effusions are then a special variety of exudate of whose genesis and pathology we remain ignorant. Perée (*Thèse de Paris,* 1881, No. 382) and Secrétan deny the possibility of lacteal rupture. The French writers have in general hesitated to admit that effusions were chylous, yet Littré early in the eighteenth century published the fourth case on record. Depoix (*Thèse de Paris,* 1889) admits the possibility of rupture. Rokitansky and Oppolzer (1861) in Austria described cases, but until twenty years ago chylous and adipose ascites were regarded in Germany as mythical. Less scepticism has been felt in America and in England where the first case was recorded.

Débove contests that Quincke cannot prove his contention that rupture of the thoracic duct explained any of the cases he reported, insomuch as they were not demonstrable post mortem. To us Débove's objection does not appear wholly valid, since lesion in the duct could well have healed before death. Débove considers it unlikely that fluid passes from the pleura to the peritoneum or from the peritoneum to the pleura. He reports an instance of chyle-like effusion into the left pleural cavity, apparently similar to Klebs' case of ascites adiposus, due to fatty endothelial cells.

DEFINITION OF TERMS.—Much confusion has arisen from inaccurate nomenclature. Chylous ascites properly designates an effusion of chyle. Adipose ascites includes fluids containing a large percentage of fat with no chylous admixture. Some authors use the term "adipose" and "chyliform" as interchangeable. Boulengier ("Contrib. a l'étude des epanch. chylif," *Presse méd. Belge,* Brux., 1890, No. 3, p. 33, and No. 4, p. 49) prefers the terms "chyliform" and "lactiform" to "chylous," on the ground that the fluid is rarely chyle. While this statement is too sweeping, yet the distinction is well made where the nature of the fluid is *sub judice.* Chyliform ascites is a chyle-like fluid in which lymph or chyle may be mixed with exudates or even transudates. It is often impossible to differentiate sharply, for two varieties may coexist or transition forms may intervene. Ascites and hydrothorax do not mean effusions of fluid into the peritoneal and thoracic cavities, but transudates into said sacs with normal vessels. Transudates are not symptoms, and the term transudates elucidates neither the etiology nor the pathology, hence the term hydrops chylosus is but imperfectly explanatory. The name hydrops adiposus, first employed by Quincke and Oppolzer, is more explicit and refers to fatty degeneration of the cells of an exudate, or implies at least that the lesion has no relation to the lymph vessels nor to their contents.

ETIOLOGY.—Excluding unruptured chyle cysts ("Chyle Cysts," excellent summary in Virchow's *Archiv,* Bd. cxxxiv., H. 1., S. 118, by Leydhecker, who also gives exhaustive review of entire pathology of thoracic duct; Weichselbaum [see table], Orth, Ziegler, Gusserow, *Charité Annalen,* 1890, p. 163), there are one hundred and fifty-five cases of adipose and chylous ascites. They occur from birth to the sixty-seventh year. Winnewarter and Kamiénski report the only cases observed in sucklings. Sex, race, occupation, and social status apparently play no causal rôle. It is striking that a little over one-half of the cases have been observed in the last decade and about three-quarters since 1870.

A. EFFUSIONS INTO PERITONEUM.

I. *Chylous.*—Solution of continuity of the vessel wall, from trauma, mural disease with transudation, etc.

Special causes:

Compression of thoracic duct or lymph system by glands, neoplasms, etc	21
Non-tuberculous peritonitis	10
Occlusion of left subclavian vein	7
Pressure, lifting, coughing, etc	5
Peritoneal cancer	5
Filaria	4
Occlusion of thoracic duct (division thrombosis, etc.)	4
Occlusion of lymph glands	3
Occlusion of lymph vessels	3
External violence	3
Malignant lymphoma	2
Liver disease	5
Syphilis	2
Primary disease (angioma) of lymph vessels	6
Calculus in receptaculum	2
Aneurism of renal artery	1
Calcification with cirrhosis of mesentery	1
Enlarged spleen	2
Pulmonary disease (stasis)	3
Nephritis	1
Heart disease	4
Sarcoma	6
Tuberculous peritonitis	1

Rupture may occur in any part of the lymphatic system; in the thoracic duct (3 cases), receptaculum (3), lacteal vessels (6), lymph gland (4), and chylous cysts (3). Chyle may extravasate into a serous effusion by mural alteration in the lymphatic vessels or by violent contraction of the abdominal muscles of the diaphragm—indeed, by intestinal peristalsis. Busey (excellent article in *American Journal of the Medical Sciences,* vol. xc., p. 373) has written upon the relation of obstructed cardiac action to lymph stasis, while Niemeyer ("Handb. d. Path. u. Therap.," Bd. i., S. 120) and Hertz (Ziemssen's "Handb. des Path. u. Ther.," Bd. xv., S. 382) have also recognized its importance.

II. *Chyliform (Adipose).*—Admixture of fatty cases (endothelial and neoplastic).

Tuberculosis of peritoneum, gland, etc	12
Carcinoma of glands, peritoneum, and lymph vessels, etc	13
Liver cirrhosis	6
Heart disease	4
Sarcoma of omentum, mesentery, etc	3
Non-tuberculous peritonitis	3
Primary fatty endothelial degeneration	1
Lipæmia	1

Busey insists that all abnormalities in the entire lymphatic system must be absent in adipose ascites: "Adipose or chyliform ascites is that variety of milky ascites in which the lymph and chyle vessels, lymph glands, lacteals, and mesentery are free from disease, distention, pressure, or obstruction, and normal in structure, size, and position. . . . We must exclude the effusion of lymph or chyle by transudation or escape by solution of continuity in any part of the lymphatic system. . . . The milky, fatty, chyle-like, opalescent fluid must necessarily be a morbid product." Senator's formula includes as possible sources, fatty degeneration of cellular and other formed elements in effusions, chiefly from endothelial cells, carcinomata, and rarely also from pus cells, fibrin, and inflammatory products. Personal experimental researches have shown that a serous ascites, produced by artificial right-heart disease, may become chyliform, which places the pure hypotheses of the French observers upon a somewhat firmer basis, and may elucidate the pathology of some of the cases reported. A chronic peritonitis may therefore result in an ascites chyliformis or adiposus. In ten cases of chyliform ascites collected from the literature, the fluid at first serous became opaque later. It is too much to say that pus infection was the cause in all instances. (In the above tabulation, it is very often most difficult to distinguish between the two types chylous and adipose.)

Nature of the Fluid.—Straus' case is the clearest example of chylous ascites—chemically typical chyle extravasated through two fistulæ. Ingested butter was recognized in the fluid withdrawn by paracentesis from the abdominal cavity, although Minkowsky (*Archiv f. exper. Pathol. u. Phar.,* 1886, Bd. xxi., p. 381–384) has concluded that fatty acids may reach the peritoneum without lymph-vessel rupture. Senator's latest case gave similar results with the administration of olive oil.

Chylous Ascites.—Diabetes must be excluded. Chylous ascites contains sugar—which fact is a diagnostic datum when diabetes is excluded. Senator, who thinks sugar one of the most constant criteria for the recognition of chyle, admits, however, that its absence is not equally significant. Sugar when primarily present may disappear later (Whitla's case). Its presence is as rare as it is suggestive, having been detected not more than two dozen times. Of late, many writers are inclined to discount the presence of sugar as a diagnostic test. Bock (*Archiv für Anatomie u. Physiologie,* 1873, p. 620) found sugar (.04 to .07 per cent.) in all cases of hydrops, and Eichhorst (*Zeitschr. f. klin. Med.*, Bd. iii., p. 537) found sugar in ten out of seventeen cases of pleural exudate. Still the copper test alone is not reliable, since boiling of Lion's casein-like substance reduced Fehling's solution.

When sugar amounts to more than .02 per cent. the effusion is chylous. Leydhecker maintains that sugar appears in the transudate only when the lymph vessels of the liver participate in the effusion. As Rotmann suggests, Leydhecker's proposition implies that the lesion of a chylous ascites must be either above the ending of the hepatic vein or that the hepatic lymphatics be assigned as a cause for the appearance of sugar in the ascitic fluid. Rotmann finds that cases in which sugar is found correspond to Leydhecker's hypothesis. Eisenschlitz concludes that the presence of sugar does not make a milky effusion a chylous transudate, since in a case of Moscatelli 0.15 per cent. of sugar was detected in an ascites from liver cirrhosis. A small amount of fat speaks for chyle. Landois estimates the percentage of fat in chyle at nine-tenths of one per cent. Chylous ascites also is rich in solids, especially mineral salts and albumen. Albumen and fat occur conjointly in small punctiform granules susceptible of differentiation by chemical tests. Microscopic examination may differentiate between chylous and adipose fluids by the size of the fat globules or fat and albumen granules.

Adipose or Chyliform Ascites.—Adipose ascites is characterized by the absence of sugar and the higher percentage of fat. The degree of opacity is no index to the amount of fat, since the turbidity may be due to the presence of emulsionized albumin. Fat occurs in most cases; its maximum percentage is 5.25 (Schmidt) and in our case 6.4 per cent., but it may be diluted by venous stasis or inflammation, while concentration of the fluid raises the percentage of fat (Minkowski). Contrary to the older conceptions, milky fluid need not contain fat, as shown by Lion's case in which a proteid, like casein, produced the opacity, as well as in the cases of Quincke, Verdelli, Achard, Sainton, Apert, Ceconi, and Basch. Fat is recognized by the osmic acid, the alkanna stain, and solubility tests. The granules of albumen and fat are much coarser in adipose than in chylous ascites. Hydropic and fatty carcinoma cells may, if numerous, cause a creamy layer, and their microscopic detection favors a diagnosis of hydrops adiposus.

Inflammatory products may obscure the pathogenesis, and hence conclusions cannot be dogmatized from every analysis. Again, the fluid changes with time, the blood absorbing parts of the original fluid—in cachexia, for example. Lymph or chyle may escape into a serous exudate or transudate of earlier origin.

The fluid, of whatever kind, usually clears with ether and caustic potash. It is said to resist decomposition on account of the emulsion of fat and a supernatant fatty layer; to which proposition one of our own cases is an exception. The reaction is usually neutral or alkaline, although it was once recorded as acid. The fluid is opalescent from suspended molecular fat and emulsionized albumen. Some fluids coagulate spontaneously, others do not. Poncy noted the odor of ingested food, while Nickerson pronounced the taste in his case cadaveric. A specimen standing ten days (Quincke, "Ueber Ascites," *Deut. Arch. für klin. Med.*, 1882, pp. 569–587) became acid, due to the formation of fatty acids. Specific gravity varies from 1.007 to 1.026, the average being 1.016. Reaction and specific gravity do not differentiate between the various forms. Macroscopically, nothing is seen except oil globules. Microscopically, fine point-like granules of fat are visible, which often have molecular movement and are soluble in ether. Large fatty cells, lymphoid, endothelial, carcinoma, and sarcoma cells are observable. Red blood discs occur, as do also fibrin (seven times), filaria (Winkel), casein (Straus and Omerod), mucin, sodium alkali albuminate (Oppolzer), bile (Omerod), acetone, hydropsin, peptone (eight times), lecithin (twice), cholesterin (three times), fibrinogen (twice), a diastatic ferment (twice), various inorganic compounds of calcium, sodium, sulphur, phosphorus, potassium, and chlorine. Urea has been recorded three times (Quincke, Remond, Foot). Tubercle bacilli have never been found. The highest percentage of albumen is 6.08 (Ballmann).

Symptomatology and Diagnosis.—The symptoms possible with such a varied etiology are not limited in number or character. The primary disease does not indicate the character of the ascites, for ascites adiposus chylosus is no morbid entity. In conjunction with chyloperitoneum, chylous fluid may be vomited (Sprague, Pellitier, Foot, Nickerson) or discharged per anum (Pellitier, Nickerson). The association of ascites with chylothorax is suggestive, even before abdominal paracentesis. The only conceivable etiological hints relate to diseased lymphatic glands and vessels, affections of the thoracic duct or left subclavian vein (*i.e.*, compression), or chyluria. "The chylous nature of an ascites may be suspected when associated with sudden anorexia, acute anæmia, and emaciation" (?). Rapid recurrence may indicate chyle fistulæ. Temperature is neither frequent nor significant. If transudation through lymph-vessel walls be the cause, the clinical course is less stormy in onset and less rapidly progressive than is observed with antecedent rupture. A diagnosis has never been made prior to puncture, except in the single instance of Morton's early case. The blood varies, of course, with the fundamental disease. Lipæmia was observed once (Popham). The local signs and symptoms do not differ from those of serous ascites. It is probable that many cases diagnosed as the vulgar ascites, healing without treatment, are instances of chylous hydrops, and the increasing frequency of the disease is best explained thereby. It is not easy to differentiate between chylous and adipose effusions as Quincke would have it, and even at necropsy an exact diagnosis is often impossible. Indeed, Senator and Leydhecker have recently spoken of mixed types. In many cases of our classification, even where full details are given, it is often difficult to decide whether the effusion be chylous or chyliform (adipose).

Prognosis.—Reference to the collected cases shows that 81 per cent. died, 8 per cent. were not followed, 11 per cent. recovered. Considering only those in which the ultimate issue is known, 88 per cent. died and 12 per cent. recovered. Bianchi says that the prognosis is better in any rupture than in cases of chylous transudation. Rupture is more likely to heal when it is due to trauma than when caused by mural disease, since thrombosis occurs more readily in trauma. Wiescher ("Zur Casuistik der Verletzung des Duct. Thoracicus," *Deut. Zeits. für klin. Chir.*, Bd. xxxviii., H. 4, 5; also contains account of experimental work upon thoracic duct), reviewing sixteen cases of chylothorax from rupture of the thoracic duct, concludes that rupture is almost invariably fatal. Rupture of the lymph vessels or receptaculum chyli may be compatible with life by the formation of thrombi and establishment of a collateral circulation (experiments of Monro, Lower, Cooper, Dupuytren, Schmidt-Muhlheim, Leichmann, Leuret, Lassaigne, Colin, Flandrin, Magendie, Noeckher, Rogerd, also citation of Wiescher above). Monro stabbed the receptaculum of a pig, but effusion was prevented by thrombosis. If there be no communication left between the blood-vascular and lymph-vascular systems, progressive inanition and death are inevitable. A chylous fistula increases the gravity of the prognosis, as copious and continuous chylous discharge is invariably fatal. I believe the immediate prognosis is better in adipose ascites. Extensive obstruction to the lymph stream is always serious. The prognosis is impressed by concomitant or causative visceral lesions. A close analysis of reported recoveries to determine favorable prognostic characters demonstrates that 3 cases were puerperal and therefore fabulous; 1 was chlorosis; 1 was compression of the thoracic duct by enlarged glands; 1 was filarious disease; 33 were ruptured lymph vessels; 5 were ruptured chyle cysts; 1 was tuberculous peritonitis; 1 was chronic recurrent peritonitis (possibly tuberculous). Only the last 2 cases were adipose, while the first 9 were chylous hydrops. Therefore the ultimate prognosis is better in chylous effusions, the converse being true of adipose accumulations. Chylous ascites is to adipose ascites as 2¼ is to 1, while recoveries stand as 5 to 1. Laparotomy improves the prognosis.

TREATMENT.—Analysis vindicates surgical interference under two restrictions: first, laparotomy is indicated as prophylaxis against possible chylous rupture with consequent constitutional depletion; second, laparotomy for tuberculous peritonitis. Paracentesis should be avoided as far as possible, save, first, as a preliminary diagnostic resort, and, second, as an ultimate resort against compression of the thoracic viscera. Otherwise puncture depletes the organism, especially in the genuine chylous form. The peritoneum should be allowed to resorb all it can of the chylous transudate. A diet readily digestible and absorbable by the stomach is advised (P. J. Murphy), to permit healing by thrombosis of ruptured lymph vessels. The use of water should be restricted. For filariosis, Lancereaux recommends mercurial inunctions and local injections into the diseased lymph glands; Guiteras remarks there is no hope short of the death of the adult worm. Other than mercurial parasiticides are probably useless. The therapy in other directions is absolutely symptomatic. *Arthur R. Edwards.*

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CHYLURIA; GALACTURIA.—DEFINITION AND ETIOLOGY.—Chyluria signifies the presence of chyle, and consequently of fat in a state of emulsion, and albumin in the urine. Sugar, a constant ingredient of chyle, is so rarely found in chyluric urine that its presence would warrant the suspicion of coincident diabetes mellitus.

There are two varieties of chyluria, the parasitic and the non-parasitic, the former being by far the more common. It has been customary to speak of these two forms as "tropical" and "non-tropical," but since the demonstration of parasitic chyluria in temperate zones this division is no longer appropriate. It is nevertheless true that in the vast majority of cases of parasitic chyluria the patients have become infected in tropical or subtropical countries. Data regarding the etiological influence of age, sex, and occupation are either scanty or absent entirely. According to Senator, chyluria has not been observed in childhood or in the aged. There is, however, no reason, in the nature of things, why it should not occur at any period of life, for its cause is mechanical obstruction of the thoracic duct and this may be seated within the calibre of that tube, in its walls, or outside of it.

Much the most common cause of chyluria is obstruction of the thoracic duct either by adult or embryonic forms of the *Filaria sanguinis hominis nocturna.* In the great majority of cases of chyluria, embryonic filariæ may be readily detected in a drop of blood from any part of the surface of the body, provided the blood be obtained at night. During the day, the embryos of filaria nocturna are very scantily present in the surface capillaries or are absent from them altogether. Manson, observing the embryonic characters of the circulating filariæ and their presence in the surface capillaries chiefly or solely during the night, came to the conclusion that they must reach a further stage of development outside of the body in the interior of some nocturnal blood-sucking animal. He exposed a patient with "*filariasis*" to the bites of mosquitoes, and found the embryos in the bodies of these insects, in which, in the course of from five to seven days, they attained a length of one-fifteenth of an inch. In the blood of man they measure from one-seventieth to one-eightieth of an inch, and are enclosed in a sheath from which they make their escape in the viscid blood of the mosquito. The mosquitoes with the embryonic filariæ in their interior seek water in which to deposit their eggs. This function accomplished, they perish; the embryonic filariæ are liberated, and through the medium of the water in which they exist, gain access to the human system. Manson's latest researches have practically demonstrated that the filaria may be transmitted directly from the infected to the non-infected by the agency of the mosquito (Culex ciliaris or pipiens) in the same manner as the Hæmatozoon malariæ is transmitted by another species of the same insect—Anopheles claviger (*Bulletin de l'Académie de Médecine*, 22 Mai, 1900). Two or more of the ingested parasites attain maturity in the lymphatic system and continue for an indefinite period (sometimes for many years) to produce swarms of embryos. The presence of filaria embryos in the blood does not necessarily give rise to disease, their transverse diameter ($\frac{1}{3500}$ inch) being, as a rule, such as to enable them to traverse the narrowest channels of the blood and lymph. Occasionally, however, they occlude these vessels, and this is believed by Manson to be due to the fact that the embryos are prematurely born enclosed in a sac or sheath of globular form, the transverse diameter of which is about $\frac{1}{750}$ inch. Disease in man occasioned by the filaria is therefore the result of disease in the filaria itself. If the adult female filaria produces the young in a physiological manner they are innocuous to their host; if, through disease or irritation, she brings them forth prematurely, they obstruct the lymph channels and cause one or more of the diseases grouped under the title of "*filariasis.*"

The principal diseases to which the filaria gives rise are abscesses, lymphangitis, dermatitis and cellulitis, erysipelas, orchitis, chyluria, chylous dropsy of the peritoneum, chylous dropsy of the tunica vaginalis, varicose groin glands, lymph scrotum, and elephantiasis. Chyluria is not common even in those countries in which filariasis prevails.

As above stated, obstruction of the thoracic duct from any cause may give rise to chyluria. As stated by Manson, the "cause of chyluria is obstruction of the thoracic duct, and this may be brought about in any climate by pressure on the duct, by tumors, by infarcts, by growths, etc.; but in the form of chyluria endemic in the tropics . . . the cause of the obstruction is the parent filaria nocturna."

A case is reported by Mr. Leigh Hunt in which transient chyluria was produced by traumatism, a fall upon a pile of stones (*British Med. Journ.*, February 22d, 1890).

SYMPTOMS AND SIGNS.—The onset of chyluria may be preceded by no symptoms whatever. In some cases, however, there is a sense of discomfort or pain in the lumbar region or the groins, the perineum or testes, before the chylous urine appears. The first symptom may be retention of urine due to the intravesical formation of coagula which occlude the neck of the bladder or the urethra.

In the great majority of cases chyluria is intermittent, being dependent, for example, upon posture, digestion, bodily exertion, etc. In one of my cases it first appeared during the expulsive pains of labor, gradually ceased after parturition, and did not return until about two years later at the birth of another child. The influence of posture is shown by the fact that in some cases the nocturnal urine is chylous while that of the day has a normal appearance. The general health is, as a rule, well maintained, although if the discharge of chyle is long continued, emaciation, anæmia, and great debility set in and the patient dies from exhaustion.

The appearance of chylous urine is highly characteristic. On careless inspection it might readily be mistaken for milk, but when examined more closely it will usually be found to contain coagula of a delicate pinkish tinge or more deeply colored like ordinary blood clots. The gross appearances, in a case of my own, are thus described: "The urine, after standing for several hours in a narrow cylindrical vessel, separates into two portions, of which the lower is distinctly hemorrhagic; while the upper has the appearance of milk or cream. Floating on the upper chylous layer are numerous coagula of a delicate, pinkish hue, and almost translucent, while at the bottom are a few small blood clots" (*Medical News*, May 2d, 1896). In some cases, after standing for a short time, the entire mass of the urine coagulates so as to resemble *blancmange*.

Diagnosis.—There is no difficulty whatever in making the diagnosis of chyluria. Lipuria, which signifies literally the presence of fat in the urine, should never be confounded with it. In chyluria the fat is in the form of an emulsion so fine as to require the strongest objectives to resolve the droplets of fat. In lipuria, on the other hand, fat globules are seen with comparatively low powers, either free or enclosed in cells or tube casts. It is very seldom that lipuria exists in such degree as to alter the macroscopic appearance of the urine, while in chyluria it commonly resembles milk. The presence of clots is also diagnostic of chyluria. The fat may be separated from chylous urine by shaking it up with ether. The ether, with the dissolved fat, rises to the surface and is then decanted. On its evaporation the fat is deposited. The urine from which the fat has been thus extracted and consequently rendered more or less transparent may now be tested for albumin, which is constantly present in greater or less degree. In addition, chylous urine contains cholesterin and lecithin, and among the albuminous bodies, in addition to serum albumin, it contains fibrinogen, hemialbumose or propeptone, and peptone. It is stated positively by Senator that chylous urine does not contain sugar. This remarkable fact—namely, the absence from chylous urine of a constant ingredient of chyle—has given rise to the opinion that chyluria is not caused by a direct admixture of chyle with the urine. In the opinion of the writer this view is absolutely refuted by the post-mortem appearances observed in cases of fatal chyluria. These consist, for the most part, of a state of varicosity of the lymphatics in immediate relation with the urinary tract. In a case of my own, "the lymphatic vessels, especially those of both renal vessels, were enormously dilated and convoluted, many of them being of the calibre of an ordinary lead pencil. The dilatation was most marked on the right side, and in the pelvis of the corresponding kidney there was a pale lymph clot similar to the coagula passed with the urine during life" (*loc. supra cit.*). In this case the communication between lymphatic and urinary tracts was practically demonstrated. It is possible that the absence of sugar from chylous urine may be due to the presence of some as yet unrecognized glycolitic ferment in the renal secretion.

In all cases of chyluria both the blood and the urine should be examined for the filaria. In the former there is little difficulty in finding it provided the blood be withdrawn (by needle puncture of finger or ear) during the night. In the urine the parasite is apt to escape detection because it is frequently enclosed in coagula. These should therefore be broken up with a glass rod and the urine allowed to stand in a conical glass, at the bottom of which the liberated filariæ may be found.

Prognosis.—The prognosis of chyluria is not unfavorable, but depends largely upon the mode of life of the patient. Manual labor and severe physical exertion of any kind tend both to develop and to perpetuate the disease. In women the pregnant condition is a serious complication.

Treatment.—With a view to prophylaxis, a sedentary occupation should be recommended in preference to one demanding physical exertion, and with the same object in view, straining at stool should be avoided by the occasional use of laxatives. As long as the urine is chylous, the strength should be maintained by nutritious food, tonics, and stimulants, and the patient kept at rest. It is doubtful whether any among the numerous remedies employed in chyluria are of the slightest direct benefit. With a view to their supposed efficacy in checking the discharge, astringent preparations of iron, gallic acid in large doses, and various vegetable decoctions containing tannin have been administered. In the parasitic form of the disease attempts have been made to destroy the filaria with thymol and other vermicides, none of which, in the opinion of the writer, has the slightest effect in this direction. I have elsewhere discussed the treatment of filariasis, and will therefore confine myself to the statement that there is no drug that will kill either the adult filaria or its embryos while they circulate in the blood, and that even if such a drug were known it would be wisest to refrain from its employment. When the adult filaria has its seat in one of the extremities and dies, an abscess usually results; or it is perhaps more correct to say that adult filariæ have been found in such abscesses, the presumption being that the latter are caused by the former. If, however, the adult filaria should die in the thoracic duct, with consequent abscess, the result would be of necessity fatal.* *Frederick P. Henry.*

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* F. P. Henry, M.D.: Report of a Case of Indigenous Parasitic Chyluria; Med. News, May 2d, 1896. Remarks on Filaria; Proceedings of the Academy of Natural Sciences of Philadelphia, 1896, p. 271.

CHYME.—The term chyme is applied to the contents of the small intestines, or, in a more restricted sense, to the matter ejected from the stomach into the duodenum during the course of digestion. It consists of food in various stages of digestion mixed with the different digestive juices. It is a mixture of extreme complexity and of very variable composition. Its composition at any one time is determined by a number of factors, the most important of which are as follows: (1) The character and composition of the food; (2) the digestive juices—the saliva, gastric, and pancreatic juices, the succus entericus and the bile; (3) the extent to which absorption has occurred; (4) the motility of the stomach and small intestines. Under normal conditions the food ingested is the most important factor in determining the character and composition of the chyme. The food not only contributes its own constituents, which may be extremely complex, but also determines, to a large extent, the amount and nature of the secretions of the glands of the alimentary tract which are added to the chyme; further, one secretion may influence another, and both a third, and all undergo certain chemical reactions with the food and with each other. The movements of the stomach and intestines are influenced largely by the character of the food and the secretions caused by it; the chyme may remain a longer or a shorter time in the intestines, and so offer the digestive juices varying opportunities to act upon it. All these factors—character of food, the secretions, and especially the intestinal movements—influence the absorption of certain constituents by the intestines.

It is obviously impossible, when dealing with such a complex and variable mixture as chyme, to give any account of either the chemical or physical properties which will apply to any but individual cases. In considering these properties it will be necessary to discuss in each case the influences modifying them.

A great many of the facts known concerning the chyme have been obtained from experiments upon the lower animals, but there have been reported a number of cases in man in which the contents of the small intestines have escaped through an artificial anus. Elaborate studies have been made in some of these cases. The case most carefully studied was one reported by Macfayden, Nencki, and Sieber (*Archiv für exper. Path. und Pharmakol.*, xxi., p. 93, 1891). These authors had under investigation a woman in whom, as a result of an operation for strangulated hernia, an *anus præternaturalis* had been established at the lower end of the ileum, and from which the chyme could be collected. Jankowski (*Archives des sciences biologiques publiés par l'instit. de méd. exper. à St. Petersbourg*, i., p. 567, 1892) studied a case very similar to the above. Other cases which may be mentioned are those of Busch (Virchow's *Archiv*, 14, p. 140, 1858), in which the fistula was but a very short distance below the duodenum; of Lossnitzer (Dissert., Leipsic, 1864); of Braune (Virchow's *Archiv*, 19, p. 470, 1860), and of Ewald (*ibid.*, 75, p. 409, 1879). The objection has been made to all such cases as these that the intestine is not in its normal condition; that when an artificial anus is established the part of the intestine immediately above becomes, functionally, the rectum; and it is thought by some that bacteria normally present in the large intestine may develop here and produce changes not normally occurring. Entirely satisfactory evidence that such objections are valid has not yet been offered, but it is important to remember them and to check the observations on patients with such fistulæ by experiments on normal animals whenever possible.

Chyme, as obtained from a fistula in man or directly from the small intestines in an animal, is a fluid or semi-pasty mass with a yellow or yellowish-brown or orange color. The chyme of the stomach or of the upper part of the duodenum is usually more grayish in appearance, although it may be colored brown from partly digested blood, or green from chlorophyl of the food. The yellow color observed in the lower part of the small intestine is due largely to the admixture of bile.

The odor of chyme is usually not very marked; that which is present resembles that of fatty acids. Occasionally it has a slightly fæcal odor (resembling indol) like that of the large intestine; but this is rare, as very little putrefactive decomposition of proteids (which is the cause of the odor of the contents of the large intestine) occurs in the small intestines.

The consistence of the chyme varies in different parts of the small intestine. When it leaves the stomach, it is a thin fluid holding solid masses of various sizes in suspension. As it passes down the intestine water (and bodies soluble in water) are absorbed; but this loss is about balanced by that added by the secretions of the digestive glands, so that the consistence remains nearly uniform in the upper two-thirds of the small intestine. In the lower third or fourth, however, the water absorbed exceeds that secreted, and the chyme becomes thicker and may be pasty or semi-solid. The nature of the food has, moreover, an important effect upon the consistence of the chyme.

The quantity of chyme which passes from the ileum into the cæcum varies greatly, being dependent largely upon the character of the food. The following figures are taken from the paper of Macfayden, Nencki, and Sieber. The patient was fed upon a diet consisting of 260 gm. of bread, 100 gm. of meat, two eggs, 200 gm. of barley gruel, 20 gm. of peptone, 60 gm. of sugar, 100 gm. of milk, and 1,050 gm. of bouillon; in addition to this she was allowed 200 gm. of water, 200 gm. of wine, and 150 gm. of "grog." The chyme was collected as it escaped from the lower end of the ileum. With the above diet, in which nitrogenous food preponderated, the intestinal contents were of thin consistence and contained on an average 5 per cent. of solids and 95 per cent. of water. At times they had the appearance of diarrhœic stools. When the patient received a vegetable diet the discharge became more consistent and contained on an average 10 per cent. of solids. The maximum amount of the thin discharge in twenty-four hours was 550 gm. with 4.9 per cent. of solids. The maximum amount of the more consistent discharge was 232 gm. with 11.23 per cent. of solids. Very similar figures were obtained by Busch, although in his patient the fistula was above the middle of the small intestine.

The solid constituents of the chyme are derived almost entirely from the food, and hence show great diversity. Before the food reaches the small intestines it has been exposed to the action of the saliva and the gastric juice and undergone marked changes—the character and extent of which are determined by the time during which it has been exposed to the action of these secretions. Foods containing proteids and gelatin are most profoundly modified. Thus, in a fragment of meat the muscle fibres have been usually separated from each other by the solution of the connective tissue binding them together; the fibres themselves are in a partially disintegrated condition, some having been split longitudinally, others transversely, forming the so-called "Bowman's discs." Some of the muscle may be completely dissolved by the gastric juice, but the chyme always contains many more or less altered muscle fibres; these are frequently in the form of a granular mass. The red corpuscles contained in the blood-vessels of the meat are partially digested in the stomach, and the hæmoglobin changed into hæmatin; the latter appears in the chyme and is one of the substances contributing to the brown color which this fluid now assumes. If much milk has been taken, masses of casein, coagulated by the rennin of the gastric juice, are found in the chyme; part of the fat is free while part is enclosed in the coagulum.

The walls of the fat cells of adipose tissue and the connective tissue binding the cells together are also dissolved by the gastric juice; the fat thus freed forms larger or smaller drops and appears in the chyme in this form. A little fat is broken up, in some way, into fatty acid in the stomach.

Pieces of tendon, elastic fibres, bone, and cartilage are not attacked by the gastric juice, and so appear in the chyme almost unaltered. Uncooked vegetable tissues are not much changed by the gastric juice owing to the membrane of cellulose, which is not dissolved in the stomach, protecting the cell contents. If the vegetables have been cooked, however, many of the cell walls have been burst and the proteids, starch, etc., of the contents exposed to the action of the gastric juice; the proteids may be for the most part dissolved, but the starch granules are scarcely altered.

Many gas bubbles are present; these consist largely of nitrogen and carbon dioxide and, to a smaller extent, of hydrogen. The nitrogen comes from the air swallowed with the food; the carbon dioxide is derived from the blood by diffusion, from fermentation of carbohydrates, and from the neutralization of the acid of the gastric juice by the carbonates of the intestinal secretions. Oxygen is not found, or is found in very small amounts; that swallowed with the air is soon absorbed.

While the chyme contains much matter in suspension, there is but very little substance in solution. If the solid parts be filtered off, the filtrate is found to contain salts, hydrochloric acid, and a small amount of peptones and albumoses and usually sugar. A piece of proteid added to this clear filtrate is rapidly dissolved, showing the presence of pepsin.

The above description applies to the chyme of the stomach, or to that which has just reached the duodenum. In the duodenum the chyme undergoes marked changes both in appearance and in chemical composition; these are brought about largely by the admixture with the bile, pancreatic juice, and succus entericus, and the chemical reactions resulting therefrom. Other factors in producing changes in the chyme are bacterial decomposition and the absorption of some of its constituents. The flow of the secretions into the intestines has long been known to be closely dependent upon the presence of the chyme in the duodenum, but the details of this relation have been worked out only in very recent years by Pawlow and his pupils (see the *Archives d. sciences biolog.*, St. Petersburg). These investigations of Pawlow, which form one of the most marked advances in the physiology of digestion of late years, show that not only does the quantity of the pancreatic juice and the bile and their rate of secretion depend upon the presence of food in the digestive tract, but also that there is a wonderful adaptation of the constituents of these secretions to the character of the food to be digested. The experiments were made upon dogs with permanent fistulæ; a few of the more important results which are of interest in this connection will be noted. We will begin with the pancreatic juice.

When the stomach was empty and the dog fasting, there was no flow whatever from the pancreatic duct; the mere sight of food, however, caused some secretion, this being brought about in part by the entrance of the acid gastric juice into the intestines. As soon as food entered the stomach an active secretion of pancreatic juice began; the amount and character of this depended upon the kind of food which had been taken. Thus, in one experiment 600 c.c. of milk caused 45 c.c. of pancreatic juice to be secreted, while 250 gm. of bread caused a secretion of 151 c.c., and 100 gm. of meat a secretion of

141 c.c. Examination of the ferments in these experiments showed that in the pancreatic juice secreted after milk the fat-splitting ferment was very abundant, whereas but little was present in that obtained after bread; the amylolytic ferment was present in larger quantities after bread than after meat. These differences in the relative amounts of the ferments were not proportional to the differences in the amount of the secretion; in fact, they might occur in an inverse proportion. Thus after milk twice as much of the fat-splitting ferment was found as after bread, although a much larger amount of pancreatic juice was obtained in the latter case. After the introduction of an emulsion of pure fat into the stomach, the fat-splitting ferment was much increased. These variations in the amounts of the ferments of the pancreatic juice show, in a marked way, an adaptation to the kind of food ingested; the secretion contains that ferment in greatest abundance which is most needed. This regulation is brought about by the nervous system; the different constituents of the food stimulate different nerve endings in the mucous membrane of the alimentary canal, and thus cause reflex changes in the pancreas of such a nature that the secreting cells produce the ferments called for. The nerve endings respond only to their specific stimuli, *i.e.*, to certain constituents of the food. Another constituent of the chyme having a specific effect upon the secretion of the pancreatic juice is the acid of the gastric juice; this causes an increase in the alkalinity of the pancreatic juice as well as an increase in the amount of fluid secreted.

A similar series of experiments has been carried out by Bruno (*Archives d. sciences biologiques*, St. Petersburg, 1899) on the factors determining the flow of bile into the intestine. His chief results may be summarized as follows: 1. The rate of the secretion of bile into the intestine is more or less typical for the various kinds of food. 2. the reaction of the contents of the small intestine is not a factor in the excretion of the bile; this is contrary to the generally accepted view. The excretion of the bile differs in this respect from that of the pancreatic juice, with which, as we have seen, the reaction of the chyme is an important factor. 3. Proteid does not act as a stimulus to the excretion of bile, although some of the products of proteid digestion do have this action. 4. Starch does not stimulate the flow of bile. 5. Fat acts as a powerful stimulus to the excretion of bile; it stimulates nerve endings in the gastro-intestinal mucous membrane, and thus causes a marked reflex excretion of bile into the intestine. Meat extract has a similar effect.

The above experiments show that the character of the food ingested has a remarkable effect upon two of the secretions into the intestine—the pancreatic juice and the bile. The relation between the food and the third of the intestinal secretions—the succus entericus—has not been very thoroughly studied, but the experiments, as far as they go, show a similar adaptation of the secretion to the food. Thus a ferment, lactase, which has the power of hydrolyzing milk sugar, can be extracted from the mucous membrane of the intestine of some animals. Weinland (*Zeitschrift für Biologie*, xxxvii., p. 229) finds that by feeding milk this ferment can be obtained from animals (*e.g.*, adult rabbits), in which it is not normally present.

We may now briefly sketch the changes which the chyme undergoes after it comes into contact with these secretions; the details of the chemical changes produced by the enzymes are discussed elsewhere in this HANDBOOK (see articles on *Digestion*, *Bile*, *Enzymes*, etc.). One of the first changes occurring in the chyme after it enters the duodenum is a change in its reaction. (In what follows we refer to the reaction which the chyme shows to litmus. As is well known, the same substance may show an alkaline reaction with one indicator and an acid reaction with another; much confusion has arisen from writers neglecting to specify the indicator used.) The chyme of the stomach has a strongly acid reaction, due largely to the hydrochloric acid of the gastric juice; all the secretions into the intestine are alkaline, largely from the presence of sodium carbonate. The hydrochloric acid and the sodium carbonate react with the formation of carbon dioxide, water, and sodium chloride. If new factors were not introduced the chyme would soon become alkaline; this was formerly universally believed to be the case. But as the hydrochloric acid is neutralized other acids are produced, so that the chyme has a variable and changeable reaction. In fact, the reaction of the contents of the small intestine has been a matter of much dispute among physiologists; this has resulted in part from the fact that different experimenters have used different methods and different animals, and in part from their neglecting the influence of food. The reaction further varies in different layers of the chyme. At the beginning of the duodenum it is doubtless acid throughout; farther down, the layer next to the intestinal wall, which comes into more intimate contact with the alkaline succus entericus, bile, and pancreatic juice, becomes alkaline while the central part is still acid. Finally toward the end of the small intestines the contents may be neutral or alkaline throughout; the latter, however, seldom seems to be the case in man—at least with a mixed diet. Thus in the patient studied by Macfayden, Nencki, and Sieber the chyme as it escaped from the lower end of the ileum was, with an ordinary diet, invariably acid; the same has been noticed in other cases. Braune, for example, found the chyme as it escaped from a fistula at the end of the ileum to be acid; if, however, the litmus paper were applied to the wall of the intestine the reaction was alkaline. Cushing (Johns Hopkins Hospital Bulletin, x., p. 136, 1899) reports a case of fistula of the upper jejunum in which the chyme expelled was invariably acid, although it had been mixed with the pancreatic juice. Busch, however, found the reaction to be alkaline in a similar case. This acid reaction is due, according to Macfayden, Nencki, and Sieber, to organic acids, and chiefly to acetic acid; hydrochloric acid is never found in the lower part of the small intestine. This acid was found to be equivalent to 0.1 per cent. acetic acid; besides acetic acid small amounts of lactic and succinic acids and volatile fatty acids were found. These acids were thought by the above-mentioned authors to be formed from carbohydrates by bacterial decomposition. Results in entire accordance with these have been obtained by Jankowski.

The results of the above authors differ from those obtained by Moore and Rockwood (*Journal of Physiology*, xxi., p. 373, 1897) in experiments upon lower animals. These investigators found the reaction of the small intestine in various classes of animals (dog, rabbit, sheep, guinea-pig, etc.) to be alkaline, the alkalinity increasing in the lower part of the intestine. Fat in the food of carnivora caused an acid reaction which persisted until the lower third of the intestine was reached; this acid reaction was, according to Moore and Rockwood, probably due to fatty acids dissolved by the bile. A carbohydrate diet caused an alkaline reaction of the chyme in carnivora —a result which would not be expected if any extensive formation of organic acids occurred from decomposition of carbohydrates. Moreover, the alkalinity of the chyme of the herbivora, which consume large quantities of carbohydrates, is normally greater than that in carnivora. These results are opposed to the view that normally much bacterial decomposition of carbohydrates occurs in the small intestine. Moore thinks it is doubtful whether the intestines in the above-mentioned patients with fistulæ were in a sufficiently normal condition to allow of trustworthy inferences being drawn as to the reaction in the intestine of man under ordinary circumstances. As regards the general health of some of these patients, there can be no doubt that it was entirely satisfactory; in fact, it seems to have been much more nearly normal than that of some of the dogs in which similar fistulæ were made for the purpose of studying the reaction of the chyme. Moreover, it is interesting to note that when Macfayden, Nencki, and Sieber's patient was given a purely vegetable diet the reaction of the chyme became neutral. On the whole, the evidence seems to be that in man with a mixed diet the chyme is acid throughout the length of the small intestine; the layer next to the walls is doubtless alkaline.

When the chyme of the stomach comes into contact with the bile in the duodenum, certain constituents of each are precipitated. Thus some of the products of the gastric digestion of proteids (syntonin and peptone) are more or less completely precipitated by the bile salts; these precipitated proteids adhere to the intestinal walls, and are consequently longer subjected to the action of the pancreatic juice than they would be if they remained in solution. The mucin of the bile is precipitated, as are also the bilirubin and cholesterin and glycocholic acid; these form a thick, resinous, colored coating of the mucous membrane. The pepsin is carried down with these precipitates, and as bile has, independently of this precipitating action, a retarding influence upon peptic digestion, the latter ceases; as soon as this mixture becomes alkaline the pepsin is destroyed. The tryptic digestion of the proteids now begins; the solid fragments of meat, etc., are eroded and the proteid converted, apparently directly, into deutero-albumose. Primary albumoses, such as are formed in peptic digestion, do not seem to be formed at all in tryptic digestion. There is some doubt as to how far the tryptic digestion of proteids is carried in the small intestine. When proteids are subjected to the action of pancreatic juice outside of the body, not only is peptone formed, but some of this is broken up into crystalline compounds of much simpler composition; among these latter are leucin, tyrosin, aspartic and glutamic acids. Macfayden, Nencki, and Sieber found neither leucin nor tyrosin in the chyme of the person upon whom they experimented; they think that if these compounds are formed in the small intestine at all, their amount must be very small and their absorption very rapid.

Fats, when they enter the duodenum from the stomach, are in the form of large drops. The pancreatic juice splits the fat (or at least a part of it) into fatty acid and glycerin; the former may be dissolved by the bile or may unite with alkalies to form soaps. When fat, soaps, and alkalies (such as are present in the bile and pancreatic and intestinal juices) are brought together an emulsion results. The conditions in the intestine are favorable for the formation of an emulsion, and, in fact, the fat of the chyme is usually in a state of fine emulsion. This change in the condition of the fat, brought about by the bile and pancreatic juice, aided, perhaps, by the peristaltic contractions of the small intestines, causes a change in the appearance of the chyme; it now becomes a creamy-looking fluid. Although the fats are usually emulsified, this is not always the case, and it does not seem necessary for their absorption; there can be no doubt, however, that their absorption is rendered much more easy and rapid when they are emulsified. What proportion of the fat is broken up into fatty acid and glycerin in the small intestine is not known. The earlier investigators thought that only a very small amount of fatty acid was formed, but this view rested upon insufficient evidence; some now hold that practically all the fat is decomposed into fatty acids, and that they are absorbed either in this form or after they have combined with alkalies to form soaps. It is also not known to what extent soaps are formed in the small intestine; the fact that very little soap can be obtained from the chyme at any one time has led to the view that it is not formed to any great extent. Others maintain, however, that the reason why so little soap is found is that it is absorbed almost as rapidly as it is formed; according to these, it is converted into neutral fat as it passes through the villi, and appears in the chyle in this form. In any case very little soap is found in the lacteals.

In whatever way the fats are absorbed, whether as an emulsion as is generally believed, or as fatty acids and soaps as some recent writers maintain, it slowly disappears from the chyme, and all observers are agreed that the pancreatic juice and bile play an important rôle in its absorption. After removal of the pancreas, or occlusion of its duct, the amount of fat absorbed is greatly diminished, and exactly the same result is observed when the bile is prevented from reaching the small intestine.

Much of the starch disappears from the chyme under the influence of the pancreatic juice; it is converted, with the formation of certain intermediate products, into sugar, which is then absorbed. The succus entericus may have an action upon carbohydrates similar to, but much less powerful than, that of the pancreatic juice. Cane sugar is inverted by the succus entericus and the invert sugar absorbed. The decomposition of starch is often not very complete, so that some of it, or of one of its decomposition products, dextrin, may be obtained from the lower part of the small intestine or from the large intestine.

Besides the changes produced in the chyme by the intestinal secretions there are others caused by the action of bacteria; there is considerable difference of opinion as to the extent and importance of these latter changes. It has even been supposed that the changes produced in the small intestine by bacteria are essential to life, but this view has been shown to be erroneous by the experiments of Nuttall and Thierfelder (*Zeitschrift für physiol. Chem.*, xxi., p. 109, 1895, and xxii., p. 62, 1896). These authors removed guinea-pigs from the uterus by Cæsarean section under strict aseptic precautions; the animals were then kept in an aseptic chamber and fed upon sterilized food. The guinea-pigs lived and did as well as normal ones fed on a similar diet. The alimentary canal was found to be entirely free from bacteria of any kind.

The most elaborate studies on the bacteria of the small intestine were made by Macfayden, Nencki, and Sieber. A number of bacteria were isolated by these investigators from the chyme as it escaped from the lower end of the ileum; the flora varied considerably from time to time and with change of diet. No bacteria were discovered which seemed to be specially bound to and constantly found in the small intestine, as is the case, for example, with the bacillus coli communis in the large intestine. "One characteristic mark, however, for the bacteria of the small intestine is this—that by preference, so to say, they decompose carbohydrates and not proteids." None of the characteristic products of the bacterial decomposition of proteids (indol, skatol, phenol, etc.) could be found; acetic, lactic, succinic, and butyric acids, ethyl alcohol, and other products of the action of bacteria upon carbohydrates were isolated. The organic acids seemed to prevent the putrefaction of the proteids. The bacteria and other micro-organisms attack not only the sugar, but also starch and cellulose; in addition to the organic acids, carbon dioxide and hydrogen are formed in considerable quantities as a result of this action. The relative amounts of these gases are determined in part by the kind of food, in part by the relative activity of the various micro-organisms. With a leguminous diet hydrogen is formed in large quantities; the same is true when the butyric-acid fermentation predominates. In other cases the amount of hydrogen may be very small; thus there was found in the small intestine of an executed criminal twenty-eight per cent. of carbon dioxide, sixty-eight per cent. of nitrogen (and oxygen), and only four per cent. of hydrogen. Marsh gas is also present at times in large amounts; this is especially abundant in the intestines of herbivora, which consume large amounts of cellulose.

From the moment when the chyme enters the duodenum until it passes into the large intestine its composition is being altered by the absorption, through the walls of the intestines, of some of its constituents. The rate and extent of absorption are dependent upon the character of the food and the time during which it remains in the small intestine. All the forms of food-stuffs are absorbed from the small intestine, but they do not all take the same path; carbohydrates, proteids, salts, and other soluble constituents pass into the blood-vessels while the fats are taken up by the lacteals. Under normal conditions the absorption in the small intestine is so complete that the chyme as it leaves the ileum has largely lost its nutritive value; Macfayden, Nencki, and Sieber, for example, found the chyme at the lower end of the ileum to contain less than one per cent. of albumin and from 0.3

to 4.75 per cent. of sugar. Some of the constituents of the secretions poured into the small intestine are reabsorbed by it; the best-known case of this kind is the reabsorption of the bile salts. Some of the water is also reabsorbed, but most of this reaches the large intestine and is absorbed there. The completeness of the absorption of the food in the small intestine is shown by the fact that patients with intestinal fistulæ through which the contents escaped without reaching the large intestine have remained in a condition of good nutrition for years. The patient of Jankowski, for example, had had a fistula at the lower end of the ileum for thirty-five years and had remained in good health; the large intestine was found atrophied from the cæcum to the rectum. Similar cases have been reported by others, and the same results obtained in experiments on animals. Harley (Proc. Roy. Soc., London, 64, p. 255) removed the entire large intestine from dogs and found that they did not suffer from malnutrition; on the contrary, they gained weight.

While all of the food-stuffs are absorbed to a greater or less extent by the small intestines, some authors state that one kind (proteids, for example), others, that other kinds (fats or carbohydrates) are best absorbed. These differences seem to depend upon the form in which the food is given rather than upon its chemical composition. In the experiments of Harley removal of the large intestine had no effect upon the absorption of fats and carbohydrates; that of proteids was decreased by ten per cent. The completeness of the absorption of proteid from the small intestine may be illustrated by the following figures from Macfayden, Nencki, and Sieber. Food containing 10.6 gm. of nitrogen was given the patient; only 1.6 gm. of nitrogen was found in the liquid escaping from the fistula in the next twenty-four hours. Thus, about six-sevenths of the proteids had been absorbed by the stomach and small intestine. That a large amount of proteid may be absorbed from the upper part of the small intestine (and stomach) is shown by the observation of Busch upon a patient who had a fistula near the lower end of the duodenum; five-eighths of the albumin and two-thirds of the gelatin given by the mouth were absorbed by this small part of the alimentary tract. In the case reported by Cushing, however, in which the fistula was also in the upper part of the jejunum, the patient suffered extremely in nutrition, not, however, from any inability on the part of the mucous membrane to absorb the food, but because the peristaltic contractions were so powerful that the food did not remain in the intestine long enough for much absorption to take place; if food of such a character was given that it did not escape easily from the fistula but occluded the opening, then considerable absorption occurred. In all cases the extent of absorption is determined in part by the time during which the chyme remains in the small intestine, and this in turn is determined to some extent by the composition of the chyme. Chyme is, in fact, the normal stimulus to the movements of the small intestine; when it contains abnormal constituents, or certain normal ones (such as cellulose and organic acids) in excessive amounts, it may so stimulate peristalsis that the contents of the small intestine are expelled before much absorption has taken place. The time during which the chyme normally remains in the small intestine was investigated by Macfayden, Nencki, and Sieber; boiled unmashed green peas (which escaped from the small intestine unchanged) or salol (which can be easily detected by its chemical reactions) were given to the patient, and the time at which they were found in the liquid escaping from the fistula observed. It was found that at least two hours elapsed before these substances appeared at the opening of the fistula, and that they continued to be discharged for nine to fourteen hours. The passage of the food mass from the ileum to the cæcum was a constant one. During the night it sank to a minimum, probably because the patient received only a stimulant now, whereas during the day she broke her fast five times. The evacuation took place without the patient being conscious of the act.

Reid Hunt.

CIBOTIUM.—*Penghawar-Djambi.* The hairy mass obtained from the rhizomes and stipes of *Cibotium Djambianum* Hook, and some other large ferns of tropical Asia and Polynesia. Besides a very extensive use in mattress-stuffing and similar work, this substance has been considerably employed as a hæmostatic. Although the juice of the rhizome is astringent and styptic, the cibotium appears to act in a purely mechanical way, like lint. In ordinary surgery we have many preferable agents, but these natural substitutes should be known to all army surgeons and others likely to require them in extreme cases.

Henry H. Rusby.

CICATRIX.—(Synonyms: Cicatrice, scar; Lat., *cicatrix;* Ger., *Narbe;* Fr., *cicatrice.*) The new tissue formed in the healing of wounds, or during the process of repair of loss of substance by disease or injury, is a cicatrix.

Old cicatrices are usually whiter than the normal skin, but may be pink or bluish, and are often pigmented. Usually depressed, smooth, and glistening, they may be elevated, or, more rarely, on a level with the surrounding skin. Pigmentation is found especially in the cicatrices of chronic and syphilitic ulcers, or when pigments or particles of coal or gunpowder have been left embedded in the skin.

Once fully formed, cicatrices are a permanent part of the body, growing with its growth, so that, if they occur of a certain relative size in a child, this relation will be found to persist in the adult. Small cicatrices occasionally entirely disappear, but this never happens when the cicatricial tissue is at all abundant. Cicatrices are thus of great importance in establishing identity. They also frequently furnish reliable information of previous disease, as in the case of cicatrices following syphilitic lesions of the skin, suppurating bubo, or suppurating joint diseases.

The structure of cicatrices is the same in all parts of the body. When a wound of skin and subcutaneous connective tissue has just healed, the young cicatrix is redder, firmer, less pliable and yielding than the surrounding parts. It may be on a level with the adjacent skin, or elevated above, or depressed below it. Its shape and size depend chiefly on those of the original gap in the tissues which it fills in. The new scar is composed of granulation tissue or embryonic connective tissue covered by a thin pellicle of epithelium. It contains no papillæ, nerves, lymphatics, muscle, or glandular tissue. In most cases the epithelial cells have been derived from the rete Malpighii of the surrounding skin. During the process of cicatrization its cells form new nuclei, and increase in size and number, and send out epidermal wandering cells. These wandering cells spread over the granulations of the wound, forming a delicate epithelial membrane that gradually diminishes in thickness toward the middle of the wound. This transparent, glistening pellicle can almost always be seen to spread inward on all sides from the edges of the wound. But it is sometimes observed to advance centrifugally from an "island" of epithelium in the midst of the wound. Usually the cells originate from sweat glands, sebaceous follicles, or epidermis that have survived the original injury. Sometimes they are derived from new cells scattered on the granulating surface by design, as by the application of skin grafts, or by accident, the cells falling unobserved on the wound while the dressings are removed. Beneath this pellicle, numerous small polygonal nucleated cells, separated by soft transparent or granular intercellular substance, are irregularly arranged in the meshes of embryonic blood-vessels. The cells are either white blood cells or connective-tissue cells. The blood-vessels are derived from those of the adjoining part by the channelling of protoplasmic sprouts. The tendency of this tissue is to develop into the white fibrous tissue found in old cicatrices. Many of the young cells are destroyed in this process; the rest become at first spindle-shaped, and finally acquire the characters of connective-tissue cells. The intercellular substance, at first not very abundant, becomes fibrillar and separates the remaining cells more widely. The whole cicatrix is now denser and drier than at first. Then the fibrillar intercellular substance contracts and condenses still further, the process only terminating when dense white fibrous tissue is formed. The contraction pulls on the neighboring parts, causing more or less wrinkling near the scar and drawing the adjacent tissues from their places. The blood-vessels also undergo changes. Many of them disappear entirely, and those which persist form a delicate anastomosing network of capillaries and small vessels communicating with those in the normal tissues on all sides of the cicatrix. The whole process is analogous to the development of embryonic tissue into adult connective tissue. In course of time, the cicatrix becomes loosened from its adhesions by the formation of adipose tissue beneath it. It becomes flexible, pliable, and easily movable, losing its adhesions to fasciæ and bone in many cases. Lymphatics and nerves also reappear, and in old cicatrices there are sometimes found a few elastic fibres. But cicatrices never contain hair, papillæ, sweat glands, or sebaceous follicles, except when they remain from the original tissue, not having been destroyed by the injury or disease that has preceded the cicatricial process. Cicatrices of mucous membranes are similar to those of the skin. They are more apt to be the cause of serious trouble on account of the greater frequency of damaging contractions, producing strictures of the mucous tubes, as of the œsophagus or urethra. Cicatrices of the glands are composed of fibrous tissue. Wounds of nerves and muscle are at first united by cicatricial tissue, but regeneration often occurs in these tissues under favorable circumstances.

Cicatrices produce certain changes in adjoining parts of the body, and are liable to defects and diseases.

The amount of contraction depends on the quantity of new cicatricial tissue and the resistance of the neighboring parts. Wounds healed by first intention are followed by much less shrinking than when allowed to granulate and suppurate. The cicatrices of burns and scalds, wounds in the flexures of joints, and lacerated wounds usually produce the greatest deformities. The remarkable contractions that follow burns are due not to any peculiarities in the structure of the cicatrix, but to the great amount of new tissue and the facility with which the surrounding tissue yields. Slight contractions at the flexures of joints may seriously interfere with their functions and greatly impair the usefulness of the limb. In many cases disfiguring and disabling contractures follow burns and wounds treated with the utmost care. They are only to be avoided by securing, where possible, the primary union of the wound. Cicatrization must be hastened by the application of skin grafts, and by careful attention to bring about the most rapid healing of the wound possible under the circumstances. Splints and bandages are sometimes of service in preventing deformities, if properly employed during and after cicatrization. But untoward results occasionally are seen, contraction beginning when the apparatus is laid aside, weeks or months after the completion of cicatrization. Or the wound may remain obstinately open while contraction is prevented, and healing will occur only at the expense of more or less extensive deformity. For the relief of deformities resulting from cicatricial contractions, apparatus may be used to stretch the scar, or various operations may be performed.

Weak cicatrices are frequently found when, during cicatrization, the granulations have been inflamed or pale and flabby. They are most common in the lower extremities and over the subcutaneous bones.

Cicatricial bands and masses may do serious damage when they contain or compress important vessels or nerves. Obstinate œdema of parts supplied by the blood-vessels may follow. Impaired motion and sensation sometimes occur when nerve trunks are compressed by cicatricial tissue. The only remedy is to dissect out the flattened nerve from the dense cicatrix, hoping that it may be subject to less pressure in its new position. When nerves are divided and their ends contained in cicatrices, besides the loss of motion and sensation the cicatrix is apt to be painful. The nerves are sometimes found to be bulbous, or the seat of fibrous degeneration. Here a portion of the nerve may be excised, or the ends dissected out of the cicatrix and sutured together.

Cicatrices also suffer from inflammation, wounds, contusions, and tumors.

Inflammation occurs in the same way as in other connective tissue. Abscess often occurs in recent cicatrices as a result of retention of some foreign body, or of infection.

Wounds of cicatrices usually heal readily.

Cicatrices sometimes undergo degenerative changes, leading to the formation of elevated, scaly, itching nodules, called keloid. This is a fibrous or fibro-cellular tumor, often of a pink color. The only treatment is excision, and the keloid is very apt to recur. It follows even slight cicatrices—for example, those of acne and chickenpox. It is more frequent, however, in cicatrices of burns and lacerated wounds.

Carcinoma of cicatrices may be either primary or secondary.

Primary carcinoma is usually of the epithelioma variety. It occurs most commonly in cicatrices situated over bones, and following burns and gunshot wounds. It usually appears in cicatrices that have been much irritated or exposed to pressure and ulcerated, and presents no unusual phenomena.

Secondary carcinoma in cicatrices usually develops in three weeks or six months from the time of operation. It may appear in the cicatricial tissue, but usually in nodules in the subjacent or surrounding connective tissue.

Sarcoma is also found occasionally in cicatrices.

Wm. G. Le Boutillier.

CICUTA AND CICUTOXIN. See *Poisonous Plants.*

CIENEGA (Manantiales de la).—These springs are situated in the low grounds between Sisal and Campeche. They are said to contain large quantities of iron.

N. J. Ponce de Léon.

CIENEGA DE MATA.—These springs, situated in the district of Jimenez, Chihuahua, Mexico, are employed in the treatment of rheumatism. *N. J. Ponce de Léon.*

CIMICIFUGA.—*Black Snakeroot. Black Cohosh.* "The rhizome and roots of *Cimicifuga racemosa* (L.) Nutt. (fam. *Ranunculaceæ*)" (U. S. P.). This is a large, perennial herb, with slender, upright stems, from one to two and a half metres high, smooth and cylindrical; they bear two or three ternately compound leaves, the lower very large, twice or thrice pinnate; the upper ones successively smaller and more simple; leaflets pointed, serrate, ovate, or more or less three-lobed. Inflorescence of one or several long, slender, upright, cylindrical racemes (25 to 50 cm. long). Flowers very numerous, something over a centimetre across, consisting of four white, concave sepals, which drop as they expand, very numerous, free, slender, spreading stamens, and a single, one-celled, ovoid pistil, containing several ovules. Petals none, a few of the outer stamens somewhat petaloid.

Cimicifuga is a common American plant, growing in Canada and in most of the United States. It is collected in various parts of the country, and has been used as a medicine for nearly a century.

The official description of the dried rhizome is as follows: "Horizontal, hard, 2 in. (5 cm.) or more long, about 1 in. (25 mm.) thick, with numerous, stout, upright, or curved branches, each terminated by a cup-shaped scar, and with numerous wiry, brittle, obtusely quadrangular roots, about one-twelfth of an inch (2 mm.) thick; the whole brownish black, nearly inodorous, and having a bitter, acrid taste. Rhizome and branches have a smooth fracture, with a large pith, surrounded by numerous sublinear, whitish wood rays, and a thin, firm bark. The roots break with a short fracture, have a thick bark, and contain a ligneous cord branching into three or four rays." Cimicifuga, it is said, should be collected in the autumn; it should be used moderately fresh, as it grows much less active with the lapse of time.

Composition.—Not satisfactorily determined: *starch, sugar, gum, resin,* which were early recognized, are common vegetable derivatives, and found in most plants. Couard obtained a neutral, crystalline, very acrid substance (allied perhaps to *anemonin*). Trimble, working more recently, was unable to get Couard's crystals, but obtained an acrid, amorphous substance. No alkaloid appears to be present, unless Couard's crystalline substance proves to be such, as surmised by Mr. Falck, who, in 1884, obtained it from the fresh rhizome.

Action and Use.—There is no question that recently dried, or, still better, fresh, cimicifuga is an active substance. Vomiting, diarrhœa, and cardiac depression are caused by large doses; faintness, restlessness, and dizziness, foul breath, and dryness of the pharynx are common results. Smaller doses are said to be tonic, to improve the appetite and digestion, and to strengthen the heart's action. It is reputed to be aphrodisiac and ecbolic, but is not at all reliable in these directions. The most important and acknowledged uses of cimicifuga are, however, established empirically. It has for many years had a reputation in chorea, and is generally believed to be useful in that obstinate disease. It is also given in chronic rheumatism, and occasionally in pulmonary troubles.

The official extract is given in doses of .06 to .5 gm. (gr. i. to viij.); the fluid extract, 2 to 4 c.c. (fl. ʒ ss. to i.); the twenty-per-cent. tincture, 2 to 8 c.c. (fl. ʒ ss. to ij.).

W. P. Bolles.

CINCHONA.—In use, this word has three distinct significations, differing in their comprehensiveness.

Cinchona L. is a genus of some forty species of trees or shrubs of the family *Rubiaceæ,* natives of the eastern slope of the Andes, from Southern Bolivia northward, many of them destitute of medicinal properties, others so inferior as not to be in use.

Cinchona, Quina, Quinquina, and *Peruvian Bark,* in materia medica, are names applied to the barks of many of the above-mentioned species, and to at least one of another genus, which contain active alkaloids. The most of these barks are so weak and inferior that their use is to be discouraged, and mention of them is deferred until the close of this article.

Cinchona and *Cinchona Succiruba,* U. S. P., are the official names of a few of these barks which reach a certain standard of alkaloidal excellence, and these will now be separately considered.

Cinchona Calisaya, Yellow Bark.

"The bark of *Cinchona Calisaya* Weddell, *Cinchona officinalis* Linné, and of hybrids of these and of other species of *Cinchona* (nat. ord. *Rubiaceæ*), yielding not less than five per cent. of total alkaloids, and at least 2.5 per cent. of quinine" (U. S. P.).

A thorough knowledge of cinchona, even of its therapeutics, calls for a perfect understanding of this definition. The name C. *Ledgeriana* Moens should precede "C. Calisaya." It was omitted by the Pharmacopœia revisers in the belief that it was but a variety of the latter, but there is little doubt that the two are distinct species, and the Ledger bark is by far the richest known. The bark of C. *officinalis,* which will be considered in our supplementary notes, never attains to the official standard, but is included because some rich hybrid barks are of its parentage. *C. Ledgeriana* and *C. Calisaya* originated in Northern Bolivia and Southern Peru, at an elevation of 2,500 to 6,000 feet. The former was always rare and was known to the natives as "Zamba," and recognized as very superior. The hybrids were not at that time differentiated, though they were recognized as being numerous. The present alkaloidal standard was rarely reached. Indeed, the barks were for a long time not examined in this way, but were selected solely upon their appearance. The threatened extermination of the species led to their cultivation, in which the Dutch and British governments were concerned. The French made early attempts, but were not concerned in the practical operations. The history of this industry is of the greatest interest, and has an extensive literature. Only the most important facts relating to it can be here considered. The attempt was made to select the best varieties and forms for cultivation. This attempt but partially succeeded, and large quantities of inferior material came into the plantations. Mistakes of nomenclature also occurred, and some of them persist to this day. At the same time, very superior varieties also came into cultivation. These were propagated as soon as recognized, at the expense of the poorer ones. The mere processes of cultivation and soil enrichment increased the richness of the barks. Hybridization occurred freely, and was resorted to artificially, and astonishingly rich products were thus originated and multiplied. Special methods of treatment were devised, such as allowing the bark to grow with the light excluded by some covering ("mossing") and removing strips of bark to allow the spaces to be again covered under the above-mentioned condition ("renewing"), which also resulted in astonishing gains in the percentage of active constituents. At the same time that this increase of quality was taking place, there was an even greater cheapening in the cost of producing and marketing. The result was that the wild barks were practically driven out of the market, and now occupy a very unimportant place in commerce.

The young bark is deficient in alkaloids. It reaches its full strength at from six to nine years of age, when the trunks are five to eight inches in diameter, and this "ripeness" is indicated by a characteristic appearance. The root bark is much richer than the stem bark.

The regions of cultivation are chiefly the Dutch East Indies, especially Java, and British India and Ceylon. Rather large areas of cultivation exist in Bolivia, but they are relatively unimportant, chiefly because of the great cost of getting the product to the coast. Mexico, Brazil, Jamaica, Australia, and Africa have had experimental plantations, but these have failed to become of importance. The bark, from selling in 1880 to 1885 at from three to four dollars per pound, is now (1889), in doubly rich quality, to be had at much less than twenty cents. The trees ultimately reach a great height and a trunk diameter of several feet. They are very beautiful, with opposite, large, luxuriant dark glossy-green leaves, often bright purple underneath, and large terminal lilac-like panicles of very fragrant flowers, white or of varying shades of pink or purple.

Description.—Detailed descriptions of the bark are for the most part no longer of importance, as manufacturers' bark, and to a great extent "druggists' bark" also, are now purchased upon the testimony of chemical assay. Nevertheless, it is perfectly easy to determine the good quality, as well as the identity of bark for pharmacists' use, by the external appearance alone. Such bark arrives mostly in the form of entire or but little broken quills. Formerly, it all arrived in this form, but economy in transportation now leads to its being broken up ("chip-bark"), and this is known as manufacturers' bark. Of this, the root bark is distinguished by a brown, instead of a gray, outer surface, and by the warped curvature of the pieces, with crookedness of grain, or striation. Inferior branch bark may be known by its thinness and the lesser roughness and lesser grayness of the outer surface. Druggists' bark, in which we are more interested, is in quills of one and a half to two feet long and one or two inches in diameter. They are frequently rolled in at both edges, the so-called "double quill." The bark is 2 to 5 mm. ($\frac{1}{10}$ to $\frac{1}{5}$ in.) thick. The inner surface is of a light cinnamon brown and finely striate, the outer bright gray (a bluish or steel gray from Bolivia, a tawny or yellowish gray from Java). Deep, for the most part completely circular, transverse fissures mark the nodes of the stem, smaller and incomplete ones being numerous in the intervening space, and much interconnected by irregularly vertical ones. The surface thus becomes cut up into angular scales resembling those upon the tarsus of a fowl. The abundance and closeness of this "chicken-leg" marking is indicative of high quality. *C. officinalis* parentage is indicated by a broad and gaping condition to these fissures, at least the principal ones, and the bark is thicker relatively to the size of the quills. A distinct longitudinal ridging is characteristic of *C. succirubra* parentage. The bast layer has a finely splintery, the outer a short, fracture. The odor is slight but characteristic, the taste bitter and slightly astringent. The powder is light yellow, whence the common name of the bark. Flat, *tabla*, or table bark is the inner bark only, flattened out, the outer surface of a cinnamon brown and smoothish.

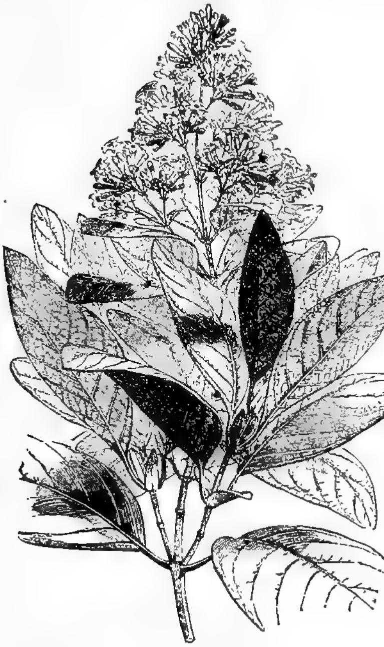

FIG. 1324.—Cinchona Calisaya. One-third natural size. (Baillon.)

COMPOSITION.—The distribution of the principal constituents of the cinchona barks will be exhibited in a table toward the close of this article. The nature and properties of the important individual alkaloids will be fully discussed after our discussion of the barks. Their percentage, absolutely and relatively to one another, varies with the age of the bark, as well as with the conditions described above. Exposure to rain during curing or in transit, or to sea water, also injuriously modifies the composition. As will be seen from the table of substances presented below, the variety now being considered contains about three per cent. of tannin, wax, gum, sugar, a trace of volatile oil, red coloring matter, and resin-like acids. These, however, do not require attention, except from pharmaceutical considerations, as calisaya is used for the antiperiodic effect of its alkaloids, more especially of the quinine. It contains from five to ten, rarely twelve to fifteen per cent., of total alkaloids, about three-fourths of which is quinine. Owing to this preponderance of quinine, calisaya is used for the effect of that alkaloid (which see), and may be considered therapeutically as its equivalent. It is like the others an excellent simple bitter and tonic, but when these effects are desired the red bark is more commonly employed. The powdered bark is sometimes given, in doses of 0.6 to 4 gm. (gr. x.–lx.), the equivalent of ♏ x. to lx. of the official fluid extract, or of gr. ss. to iij. of quinine. The official extract is given in doses of 0.3 to 1 gm. (gr. v.–xv.), the 20-per-cent. tincture, 2 to 8 c.c. (fl. ʒ ss.–ij.), and the 6-per-cent. infusion, 30 to 60 c.c. (fl. ℥ i.–ij.).

CINCHONA RUBRA, RED CINCHONA.

"The bark of *Cinchona succirubra* Pavon, containing not less than five per cent. of its peculiar alkaloids" (U. S. P.). This tree is native upon the slopes of Mount Chimborazo and, like the last, becomes a large tree. It also has been largely introduced to cultivation in the East Indies, but has not, in consequence, undergone such great changes. Its characters can be best discussed by comparing it with the last.

It more frequently occurs in quills, and the bark is commonly thicker and more splintery in fractures. The inner surface is usually, though not always, of a deeper color, varying to deep red. The outer surface, in typical samples, is almost wanting in the checkered, scaly appearance, and indeed fissures are commonly almost wanting. It has instead longitudinal ridges, originating in rows of warts which afterward become confluent. In old barks, these ridges become fissured longitudinally. The powder is of a deep red, which gives the common name to the bark. In general, its composition is the same as that of calisaya. It, however, contains far more red coloring matter and more astringent principles, and only about one-fifth of its alkaloid is quinine, the rest being mostly cinchonidine and cinchonine. Its properties differ accordingly. It is accounted decidedly inferior as an antiperiodic, and its use is commonly as a vegetable bitter. However, following the differences in the alkaloids described below, this is no mean antiperiodic, and is frequently of great service in cases not favorably influenced by quinine. The only official preparation is the compound tincture, or Huxham's Tincture, consisting of ten per cent. of this bark, eight of bitter orange peel, two of serpentaria, and seven and one-half of glycerin. The dose is 4 to 16 c.c. (fl. ʒ i.–iv.).

THE CINCHONA ALKALOIDS.

The alkaloids reported in cinchona barks are numerous. Many of them are known or believed to have originated in the chemical manipulation of the bark. Others exist in very small amount, or in barks which possess but little value. Most of them are therefore of chemical interest merely, and only those of practical importance will be here discussed.

Quinine ($C_{20}H_{24}N_2O_2 + 3H_2O$) is the most common, abundant, active, and important, and is thus described in the Pharmacopœia:

A white, flaky, amorphous, or crystalline powder, odorless, and having a very bitter taste; permanent in the air.

Soluble, at 15° C. (59° F.), in 1,670 parts of water, and in 6 parts of alcohol; in 760 parts of boiling water, and in 2 parts of boiling alcohol; in 23 parts of ether, 5 parts of chloroform, and 200 parts of glycerin; also soluble in carbon disulphide, benzin, benzol, ammonia water, and diluted acids.

When heated to about 57° C. (134.6° F.), it melts; at 100° C. (212° F.), it loses about 9 per cent. (or about two molecules) of its water of crystallization, the remainder being expelled at 125° C. (257° F.). The anhydrous alkaloid, when pure, melts at 173° C. (343.4° F.). Upon ignition it is consumed, leaving no residue.

Quinine has an alkaline reaction upon litmus paper.

A solution of quinine in diluted sulphuric acid has a vivid, blue fluorescence.

On treating 10 c.c. of an aqueous, acidulated solution (about 1 in 1,500) of quinine with two drops of bromine water, and then with an excess of ammonia water, the liquid will acquire an emerald-green color. With proper adjustment of the reagents, more dilute solutions will give a paler tint, while more concentrated ones will acquire a deeper color, or deposit a green precipitate.

Quinine should not impart more than a faintly yellowish tint to concentrated sulphuric acid (limit of *readily carbonizable, organic impurities*), nor produce a red color with nitric acid (difference from *morphine*).

If 2 gm. of quinine be mixed, in a small mortar, with 1 gm. of ammonium sulphate and 10 c.c. of distilled water, the mixture thoroughly dried on a water-bath, the residue (which should be strictly neutral to test paper) agitated with 20 c.c. of water, then allowed to macerate for half an hour at 15° C. (59° F.), with occasional agitation, and filtered through a pellet of glass-wool, 5 c.c. of the filtrate, transferred to a test tube and gently mixed, without shaking, with 7 c.c. of ammonia water (specific gravity, 0.960), should produce a clear liquid. If the temperature during the maceration has been 16° C. (60.8° F.), 7.5 c.c. of ammonia water may be added; if 17° C. (62.8° F.), 8 c.c. (In each case, a clear liquid indicates the absence of more than small proportions of *other cinchona alkaloids.*)

Quinine yields two official preparations. *Ferri et Quininæ Citras*, or Citrate of Iron and Quinine, contains 85 per cent. of ferric citrate, 3 of citric acid, and 12 of quinine. It is slowly soluble in water and not completely soluble in alcohol. The soluble form (*Ferri et Quininæ Citras Solubilis*) is made with the addition of a little ammonia water, and is rapidly soluble in water. It is in greenish, golden-yellow scales; the former in reddish-brown scales. The dose of each is 0.3 to 0.6 gm. (gr. v.–x.). The soluble form is used to make the bitter wine of iron (*Vinum Ferri Amarum*).

A very great number of salts, as well as a number of double salts, have been formed with quinine, nearly a hundred in all being listed by manufacturers. The following are official.

Quinine Sulphate, soluble in 740 parts of water, 30 of boiling water, or 65 of alcohol. It is neutral to litmus paper. About three-fourths of it is quinine. It enters into the formation of the official *Syrupus Ferri Quininæ et Strychninæ Phosphatum*, the dose of which is 4 to 8 c.c. (fl. ʒ i. to ij.).

Quinine Bisulphate, soluble in 10 parts of water and 32 of alcohol, and acid to litmus paper. About five-eighths of it is quinine.

Quinine Hydrobromide, soluble in 54 parts of water and 0.6 of alcohol, neutral or faintly alkaline to litmus paper.

Quinine Hydrochloride, soluble in 34 parts of water and 3 of alcohol, reaction like the last.

Quinine Valerianate, soluble in 100 parts of water and 5 of alcohol, reaction like the last.

The acetate, citrate, bitartrate, benzoate, salicylate, and phosphate are also considerably used, as is the carbamide (hydrochlorate of quinine and urea). Being very soluble, they are specially useful for hypodermic injection.

The quinate is supplied on the guess that, being the natural salt of the living plant, it might be more efficient. It is very soluble in both water and alcohol, and is used hypodermically.

The tannate has been very much used, but most testimony is against its efficacy. It has little taste, but this is because of its great insolubility.

The arsenite, arsenate, antimonate, etc., may be regarded rather as medicinal forms of the associated substances.

Action and Uses of Quinine.—In using quinine it is always to be borne in mind that under alkaline conditions it is precipitated. The antiseptic properties of quinine are very similar to those of salicylic acid. It is especially antizymotic, and one-half per cent. may be added as a preservative to solutions. Advantage is taken of this property to prevent urinary decomposition by injecting it into the bladder. It may also be applied in powder or solution to unhealthy sores as a disinfectant. It is at the same time stimulating to the healing tissues, but care must be taken to avoid undue irritation. As a parasiticide it works very irregularly and, upon the whole, uncertainly; yet its domestic repute as a hair tonic is probably due to some destructive or inhibitory effect upon the micro-organisms of the scalp. A solution painted upon the nares has in some cases aborted an attack of hay fever, but the mode of action is uncertain.

Quinine, so applied as to be maintained in solution, is stimulant or irritant to mucous membranes. It possesses precisely the same appetizing, stomachic, and tonic properties as other vegetable bitters, tends like them to inhibit digestion of the food mass in which it is contained, and, like them, should be administered for these purposes in small doses, well diluted and taken slowly just before meals. After long administration, gastric irritation and indigestion are very apt to be produced and may be reflected by an erythematous or urticarious eruption of the skin. In some persons even small doses will produce these very distressing symptoms. The reflex stimulation of quinine through the stomach appears to be rather unimportant. Its absorption is almost, if not wholly, from the stomach, so that the conditions for rapid absorption should be secured. There should be an abundance of water taken with it, and if drink is avoided for some time previous to the dose absorption is favored. A slight amount of alcohol favors absorption. If these conditions are observed, the very large doses required in treating the pernicious malarias of the tropics can be readily absorbed. In most cases, quinine is a remedy the effect of which is particularly strengthened by prompt absorption. Authorities are agreed that it exists in the blood as the chloride. It favors alkalinity of the blood. Elimination is almost wholly by the kidneys, except for the unabsorbed portion which passes out with the fæces. Elimination begins very quickly but proceeds rather slowly.

Concerning the systemic effects of quinine after absorption, a very great amount of research has been recorded. The results are here very briefly summarized for the reason that their bearing upon the two leading therapeutic uses of the drug is very simple, and other relations will be discussed under Toxicology.

Its most important power is that of killing the malarial plasmodia and of inhibiting their propagation. This it does directly, promptly, and in proportion to the percentage in solution in the blood. This perfectly explains its antiperiodic properties, but not its effects in removing neuralgia and other sequelæ of malaria after the disappearance of the plasmodia from the system. It is natural to ascribe these results to the tonic action, through nutritive restoration; but sometimes the result is immediate, from large doses, and it must be due to some unexplained nerve action.

Its next most important effect is to reduce the temperature of fever, which it will not do to the normal temperature. This is done in two ways: 1. The drug has a marked power to lessen the oxidation of hæmoglobin, as well as the transfer of oxygen to the tissues, thus decreasing heat production. 2. It inhibits the heat-producing centres. All metabolism and tissue waste are strongly checked, one of the factors favorable to its tonic action; consequently there is markedly decreased elimination of urea, uric acid, etc.

The above facts will partly explain the power of quinine to check inflammatory processes. This is further explained by the fact that the drug is a general depressant of vital power. It depresses both the irritability and power of muscular tissue, being thus a cardiac and arterial depressant. In this way, and by acting upon the cardiac ganglia and the vaso-motor centres, it markedly reduces blood pressure. It must be understood, however, that this is a secondary effect and an effect of large doses, and that it is possible to so administer small doses as to get a slight vaso-motor and cardiac stimulation, not followed by any appreciable reaction.

These facts in turn have a bearing upon the power of quinine to inhibit pus formation. The further claim is made that it checks the migration of leucocytes, as it certainly lessens their activity. Although the counter claim is made that this migration is checked only by impracticably strong solutions, the former view appears sustained. The reflex inhibitory centres are also stimulated, resulting in a pseudo-reflex depression.

Quinine causes contraction of the spleen, especially if enlarged. The cerebral effect appears in contrast to the generally depressing effects, being that of a direct and prolonged increase of circulation, with correspondingly increased functional activity. This contrast is in reality misleading, as the principal cause appears to be depression or paralysis of the arterial walls, leading to local congestion. The symptoms induced constitute the state known as cinchonism, in which there is fulness in the head and often a slight dull headache, ringing in the ears, usually with some deafness, and some disorders of vision. These symptoms are taken to indicate the full physiological effect of the drug, and preliminary to acute poisoning, in which there are dizziness, blindness, and unsteady gait, going on to great muscular depression, convulsions, and generally the condition of collapse, with failure of respiration.

Most of the uses of quinine are directly in line with its activities as above defined. As a tonic and restorative, one to three grains may be given before meals for some time.

In malaria, its great field of usefulness, the methods of administration differ widely. There are two principal rules, one to administer a few large doses, the other many small doses, and each has many adherents. The latter method is most likely to disturb the stomach. Proximity of the paroxysms to one another frequently renders the former method unavoidable, as the effects of administration during the paroxysm are not so favorable. It has been suggested that just after a paroxysm of fever the plasmodia are at their weakest and hence most easily affected by the quinine. All considered, the most rational method appears to be the administration of a large dose of five to ten grains just after the paroxysm and then say two grains every two hours to keep the system under its influence until the danger of recurring attacks is past. At intervals of seven days there is special danger of recurrence, and the prophylactic dose should be doubled at that time. After each seven days the dose may be progressively reduced, ceasing after the twenty-eighth day. If the patient continue exposed to infection, the cure need not be regarded as permanent except upon the best of evidence, and many such persons have to take quinine habitually. There can be no question of the frequent injuriousness of the drug under such circumstances, in spite of all statements to the contrary. Gastric and cutaneous disorders, as well as disturbances of sight and hearing, are not uncommon. Quinine should be used with caution when there is aural inflammation, and generally when cerebral congestion exists, and it should be lessened when gastric irritation comes on.

In the pernicious malaria of the tropics, very large doses, up to fifty or sixty grains, preferably of the bisulphate, with abundance of water, often prevents immediate death, and permits of cure. A little alcohol greatly aids its action. The disagreeable cerebral symptoms which would ensue from such large doses may be avoided by an accompanying dose of bromide. The use of mercurials favors the effects of quinine. The certainty of the antiperiodic action of quinine was established by an Indian Government commission, which determined the proportion of failures to be not more than seven per thousand cases.

The antipyretic action of this alkaloid can be secured by the administration of twenty grains or more. If the temperature is ascending at the time, more is required. It is then also slower in its action, requiring only about an hour under the most favorable circumstances.

Acute tonsillitis is apt to be most favorably affected by a prompt dose of ten grains, and an impending cold may often be averted in the same way. Here, again, a small or moderate dose of alcohol will emphasize the effect of the quinine.

Various methods have been resorted to to disguise the bitter taste of this drug, exceedingly objectionable to many persons. The use of tannin and substances containing it weakens its medicinal effect. Yerba santa probably acts chiefly in this way. Probably there is nothing, in the liquid form, better than licorice for this purpose. The best general method, however, is the use of the soft gelatin capsule, or, almost as good, the ordinary hard gelatin capsule.

OTHER ALKALOIDS.—The only other alkaloids which require mention are quinidine, cinchonidine, and cinchonine, the last of comparatively little value. As to dosage, it is taught that for antiperiodic purposes, the dose of quinidine and cinchonidine is about one-third more than that of quinine, that of cinchonine double that of quinine. The failures per thousand stand 6 for quinidine, 7 for quinine, 10 for cinchonidine, 23 for cinchonine. The relative antipyretic effects are, quinine 10, quinidine 9, cinchonidine 7, cinchonine 4. As stomachics and tonics, there is little difference among them, with the injurious effects more pronounced from quinine. Cinchonidine, and still more cinchonine, is less apt to cause the disagreeable effects of cinchonism, and they may frequently be given to those who cannot tolerate quinine. Cinchonine and its sulphate, and the sulphates of cinchonidine and quinidine, are official and their descriptions follow, as well as brief accounts of some rather important alkaloidal substances.

Cinchonina or Cinchonine ($C_{19}H_{22}N_2O$).—White, lustrous prisms or needles, without odor, at first almost tasteless, but soon developing a bitter after-taste, and permanent in the air.

Soluble, at 15° C. (59° F.), in 3,760 parts of water, and in 116 parts of alcohol; in 3,500 parts of boiling water, and in 26.5 parts of boiling alcohol. Also soluble in 526 parts of ether, and in 163 parts of chloroform.

At 240° C. (464° F.) the crystals fuse together, and at 258° C. (496.4° F.) they melt, forming a brown liquid. When ignited, they are consumed without leaving a residue.

When placed on moistened red litmus paper, cinchonine shows an alkaline reaction.

On adding to a neutral or not more than faintly acid solution of cinchonine, or of one of its salts, enough potassium ferrocyanide T. S. to redissolve the precipitate first formed, and afterward an acid, a golden-yellow precipitate will be formed, which, when redissolved by gently warming the liquid, will separate, on cooling, in minute scales or needles.

On adding an excess of ammonia water to a solution of cinchonine in a dilute acid, the alkaloid will be precipitated.

The precipitate is but feebly soluble in ammonia, and should require not less than 300 parts of ether for solution.

Its sulphate is neutral, and is soluble in 66 parts of water and in 10 of alcohol.

Cinchonidine Sulphate ($(C_{19}H_{22}N_2O)_2H_2SO_4 + 3H_2O$).—White, silky, acicular crystals, without odor, having a very bitter taste and slightly efflorescent on exposure to air.

Soluble, at 15° C. (59° F.), in 70 parts of water, and in 66 parts of alcohol in 1.42 parts of boiling water, and in 8 parts of boiling alcohol. Also soluble in 1,316 parts of chloroform, and almost insoluble in ether. The presence of sulphates of other cinchona alkaloids increases its solubility in ether and chloroform.

At 100° C. (212° F.) the salt gives off its water of crystallization. At 215° C. (419° F.) it melts, and, when ignited, it is consumed without leaving a residue.

The salt is neutral, or has a faintly alkaline reaction on litmus paper.

On adding ammonia water to the aqueous solution of the salt, a white precipitate (cinchonidine) is produced, which is but slightly soluble in ammonia, but dissolves in about 75 parts of ether.

If concentrated sulphuric acid be added to a small quantity of the salt, not more than a faintly yellowish color should be developed (limit of *readily carbonizable, organic impurities*). Upon adding to this liquid a crystal of potassium dichromate, a yellowish-green color is produced, which gradually changes to grass-green.

Addition of barium chloride T. S. to an aqueous solution of the salt produces a white precipitate insoluble in hydrochloric acid.

A solution of the salt (about 1 in 1,000) in diluted sulphuric acid should not exhibit more than a faint blue fluorescence (absence of more than traces of the *sulphates of quinine* or *quinidine*).

If 1 gm. of the salt be dried at 100° C. (212° F.) until it ceases to lose weight, the residue, cooled in a desiccator, should weigh not less than 0.920 gm. (absence of an *undue amount of water*).

If 0.5 gm. of the salt be macerated, with frequent agitation, at the ordinary temperature, with 20 c.c. of distilled water, 0.5 gm. of potassium sodium tartrate then added, the maceration continued, under repeated agitation, for one hour at 15° C. (59° F.), and the mixture then filtered, the addition of one drop of ammonia water to the filtrate should not produce more than a slight turbidity (absence of more than small proportions of the *sulphates of cinchonine* or *quinidine*).

Quinidine Sulphate $(C_{20}H_{24}N_2O_2)_2H_2SO_4 + 2H_2O$ is soluble in 100 parts of water or in 8 of alcohol, and is neutral or faintly alkaline.

Quinoidine, Chinoidine, or *Black Stick*, is a blackish, resinous, alkaloidal mass precipitated from the mother liquor and without definite composition. It is nearly equal in efficacy to quinine, and may often be used in the same dose as quinine in chronic malaria, when other alkaloids have failed, or when quinine cannot be used.

Febrifuge is a name applied to an alkaloidal mass manufactured in India as a cheap substitute for quinine for home consumption. One form is made of the total alkaloids of red bark, another as a by-product after the extraction of quinine, with the addition of the alkaloids of some hybrid bark. It is used on an immense scale. Its composition is reported by Hooper (*Pharmacographia Indica*) as quinine 15.1 per cent., cinchonidine 29 per cent., cinchonine 33.5 per cent., amorphous alkaloids 17 per cent. It is a pale yellowish-white powder, of peculiar odor. The dose is slightly larger than that of quinine.

UNOFFICIAL CINCHONA BARKS.

Only two of these are important, namely, Pale Bark and Maracaibo Bark.

Pale Bark.—This is the product of *Cinchona officinalis* L. and its several varieties. These vary so greatly in appearance that there are various forms of this bark recognized, as Crown, Huanuco, Cuenca, Loxa or Loja. The native bark came from Ecuador, and still does so in rather large amounts. It comes from large shrubs and occurs in rather crooked, thin quills, from the thickness of a lead pencil to that of the finger, and is rather thick for the size of the quill. It is generally of a dark brown, the Huanuco a rather light brown, and is very apt to be excessively shaggy with lichens, when it is highly prized and really contains more alkaloid, as a result of the exclusion of light during growth. It is less bitter than the other barks. It and various hybrids have come largely into cultivation, but this cultivation is not now continued on the same scale. These hybrid forms grow much larger, the quills becoming as large as an ordinary calisaya. They retain their proportionally greater thickness. They are usually of a dingy gray and the fissures are wide and gaping. The color of the powder is very light, giving the name "pale." This bark (if typical) usually contains about three per cent. of alkaloids, one-half to nearly two-thirds being quinine. It is chiefly consumed in Southern Europe. It was formerly official, and its fluid extract is still a favorite with many American physicians. This preference is however erroneous, unless a double dose is given to secure the same effect.

Maracaibo Bark.—This is from one of the most northerly growing species. What that species is, is not certain. The bark occurs in warped, chip-like, thick pieces commonly as large as the hand, and is of coarsely striated structure, and hard and heavy. It is of a bright but pale yellow, with silvery soft patches of periderm easily scraped off with the thumb-nail. Its only interest is because many ignorant pharmacists purchase it, under the name of "yellow bark," for calisaya. It is quite worthless except as a vegetable bitter, containing a great amount of resin, but practically no quinine or other valuable alkaloid.

The other unofficial barks, Cuprea, Pitaya, Gray, Hard, and Soft Colombian, Hard and Fibrous Carthagena, Hamalies, Cuzco, Cocola, Pajinal, are in the market, if at all, only as relics. They are no longer collected. When cinchona was valuable, great quantities of these were accumulated in London, and when the price fell they were stored to await a favorable market. This never came, and many tons are still there, for which their owners would be glad to take five per cent. of the cost price. From time to time small quantities of these are worked off upon ignorant or careless buyers, but their use can be regarded only as objectionable.

Remijia.—One of these, Cuprea Bark, is the product of the related genus Remijea and contains a small amount of quinine.

The following composition table by Dr. Bolles, taken from the last edition of this work, is of interest:

1. ALKALOIDS.

Name.	Discovery.	Composition.	Source.
Quinine......	Pelletier and Caventou, 1820.	$C_{20}H_{24}N_2O_2$.	In all the best cinchonas, especially *C. Calisaya*, *Ledgeriana*, *officinalis*, *lancifolia*, *pitayensis*, etc., associated with cinchonine, etc.
Quinidine....	Henry and Delondre, 1833.	Same formula	*C. pitayensis* and other good species.
Cinchonine...	Pelletier and Caventou, 1820.	$C_{19}H_{22}N_2O_2$.	Red bark, *C. succirubra*, also in most of the others, common and abundant.
Cinchonidine.	Winckler, 1847..	Same formula	*C. tucujensis*, also in other species.
Homocinchonidine.	Hesse, 1877.....	$C_{19}H_{22}N_2O_2$.	South American red bark.
Quinamine...	Hesse, 1872.....	$C_{19}H_{24}N_2O$.	*C. Ledgeriana*, *officinalis*, etc., also in *Remijia*.
Cinchamidine	Hesse, 1881.....	$C_{20}H_{26}N_2O$.	From the mother liquor of homocinchonidine. Frequently present in commercial cinchonidine.
Aricine......	Pelletier and Coriol, 1829...	$C_{23}H_{26}N_2O_4$.	*C. pubescens*, etc., Arica or cusco bark.
Cusconine....	Hesse, 1877.....	$C_{23}H_{26}N_2O_4$.	Accompanying the above.
Cusconidine..	Hesse, 1877.....	Not analyzed.	
Cuscamine...	Hesse, 1880	Not analyzed.	*C pelletieriana* ("cusco bark").
Cuscamidine..	Hesse, 1880		
Paricine.....	Winckler, 1844..	....	*C. succirubra* (Hesse, 1877).
2. ACIDS.			
Cinchonic acid, kinic acid.	Hoffman, 1790..	$C_7H_{12}O_6$.	In all cinchonas and many other plants. A widely distributed vegetable acid.
Chinovic acid.	Hlasiwetz......	$C_{24}H_{38}O_4$.	In cultivated cinchonas; probably more general. Also in Tormentilla.
Cinchotannic acid.	Berzelius......	....	All cinchonas.
3. NEUTRAL AND MISCELLANEOUS.			
Chinovin. A glucoside...	Pelletier and Caventou, 1821.	$C_{30}H_{38}O_8$.	Cinchonas, Remijias, and other *Cinchoneæ*.
Cinchona red.	Reuss, 1812.....	$C_{28}H_{32}O_{14}$.	All cinchonas, especially the red.
Lignoin......	Reichel, 1856...	$C_{20}H_{23}NO_8$.	Cinchonas—doubtful substance.
Cinchocerotin.	Kerner, 1859...	$C_{27}H_{48}O_2$.	Calisaya.
Water........			

Henry H. Rusby.

CINCINNATI, the chief city of Ohio, is situated on the north bank of the Ohio River. "It is surrounded by hills from 400 to 465 feet in height, forming one of the most beautiful amphitheatres on the continent, from whose hilltops may be seen the splendid panorama of the cities below, and the winding Ohio" (Appleton's "Guide to the United States and Canada"). It is a city of three hundred thousand or more inhabitants, more than a third of whom are Germans or of German parentage. The chief public park is Eden Park, situated on a hill affording a striking view of the city, the valley of the Ohio, and the surrounding country. The climate is indicated by the accompanying chart.

CLIMATE OF CINCINNATI, OHIO.—LATITUDE, 39° 6′; LONGITUDE, 84° 30′. PERIOD OF OBSERVATIONS, DECEMBER 1ST, 1870, TO DECEMBER 31ST, 1883.

Data.	January.	July.	Year.
Temperature (Fahr.)			
Average or normal	34.4°	78.3°	55.90°
Average daily range	14.0	16.3	
Mean of warmest	41.4	86.8	
Mean of coldest	27.4	70.5	
Highest or maximum	69.0	103.5	
Lowest or minimum	−10.0	58.2	
Humidity—			
Average relative	72.3%	64.4%	66%
Precipitation—			
Average in inches	3.54	4.29	44.36
Wind—			
Prevailing direction	S.W.	S.W.	N.W.
Average hourly velocity in miles	6.4	4.8	5.8
Weather—			
Average number of clear days	4.8	9.2	94.9
Average number of fair days	10.2	13.2	140.4
Average number of clear and fair days	15.0	21.4	235.3

E. O. Otis.

CINCINNATI ARTESIAN WELL.

CINCINNATI ARTESIAN WELL.—Hamilton County, Ohio. This well is located at the Cincinnati gas-works, and is 1,245 feet in depth. There is a continuous flow of water. The following analysis is by E. S. Wayne:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium carbonate	8.14
Calcium carbonate	17.33
Potassium sulphate	27.27
Sodium chloride	519.60
Magnesium chloride	18.14
Calcium chloride	22.26
Potassium chloride	3.27
Magnesium bromide	.26
Magnesium iodide	.19
Iron oxide	.37
Silica	.49
Total	617.32
Gases.	**Cu. in.**
Sulphureted hydrogen	7.76
Carbonic acid	10.32

This is a very rich saline sulphureted water, and ought to be of value in the treatment of diseases for which such waters are used. *James K. Crook.*

CINNAMIC ACID AND CINNAMATES.

CINNAMIC ACID AND CINNAMATES.—Cinnamic or *phenyl-acrylic* acid ($C_9H_8O_2$) results from oxidation of oil of cinnamon, the oil being chemically cinnamic aldehyde, and it also exists ready formed in conjunction with benzoic acid, to which it is closely related, in many balsams, such as the balsams of tolu, of Peru, and of benzoin. It can be formed synthetically also. Cinnamic acid is a colorless crystalline body, volatilizable without taste or smell, freely soluble in alcohol, but only feebly so in water (one-tenth per cent.). The commercial article is obtained chiefly from styrax.

Cinnamic acid is non-poisonous, and is said to resemble salicylic and benzoic acids in antiseptic power. It has been suggested as a practical antiseptic for use in surgical dressings. Lint, jute, etc., may be charged with the acid by soakage in an alcoholic solution. It has also been employed for the constitutional treatment of phthisis, by the intravenous injection, twice a week, of a few minims of a five-per-cent. emulsion of the acid. Such injection is practised upon a vein of the forearm, with proper antiseptic precautions, and the treatment continued for at least three months.

Cinnamic acid is oxidized readily into benzoic acid, and it is supposed that this action takes place in the human system, since the two acids have the same effect upon the urine and its constituents.

Sodium cinnamate is a salt freely soluble in water, and has been proposed as a substitute for cinnamic acid because of such free solubility. *Edward Curtis.*

CINNAMON.

CINNAMON.—The cinnamon products include cinnamon and cassia barks, cassia chips, cassia leaves and cassia flowers, and the oils distilled therefrom. They are all yielded by species of the genus *Cinnamomum* Blume, in the family *Lauraceæ.* The genus contains some fifty-four species, all natives of tropical Asia and Australasia. The section containing the camphor tree is markedly distinct, and would probably be better regarded as forming a separate genus. Many of the species yield useful products of minor importance, and these will be enumerated at the close of this article. Three species, two of them known, the third doubtful, yield the highly esteemed and official cinnamon barks, and will now be considered separately.

1. CEYLON CINNAMON, CINNAMOMUM ZEYLANICUM.—"The inner bark of the shoots of *Cinnamomum Zeylanicum* Breyne" (U. S. P.). This well-known species is a native of the hills and woods of the island of Ceylon. It has also been long cultivated in the same island, and it is from these cultivated plants that all the true cinnamon now comes. It has also been introduced into other islands of the Indian Ocean, and into the mainland of Asia, as well as into the West Indies, but it produces in these places inferior barks. On the cinnamon plantations the trees are trimmed down to make them send up sprouts from the base; these are allowed to grow until they are about two years old and 3 or 4 cm. in diameter, when they are cut, and the bark is peeled off in pieces about 30 cm. (1 ft.) in length. These strips are then put together in rolls and allowed to wilt for a day or so, when they are separated and each piece is laid upon a suitable stick around which it will fit, and the outer cellular layers of the bark are scraped off and rejected. The quills of inner bark so prepared constitute cinnamon, and are rolled together in successive layers until a solid cylinder about a metre long and 1.5 or 2 cm. thick is formed (1 yd. by 0.5 or 0.75 in.), of sometimes a dozen layers of brittle, splintery bark. The Pharmacopœia thus describes the bark:

"*Ceylon cinnamon* is in long, closely rolled quills, composed of eight or more layers of bark of the thickness of paper; pale yellowish brown; outer surface smooth, marked with wavy lines; inner surface scarcely striate; fracture splintery; odor fragrant; taste sweet and warmly aromatic."

This is altogether the finest, and in general the best cinnamon of the market, though it is not nearly so strong, sweet, or expensive as the third variety. If taken young and of good quality, it has scarcely a trace of bitterness and but little astringency. It contains only a moderate amount of sugar and mucilage. It yields a large percentage (up to five per cent.) of ash. It is rich in oil, yielding up to one and a half per cent., and this oil is very fragrant. The features of this cinnamon, as a perfuming and flavoring agent, are its delicacy and permanence. It is the only species official in the British Pharmacopœia.

2. CASSIA CINNAMON, CINNAMOMUM CASSIA, CASSIA LIGNEA, CASSIA VERA.—"The bark of the shoots of one or more undetermined species of Cinnamomum grown in China" (U. S. P.). In spite of this statement, the article is known to be the product of *C. Cassia* (Nees) Blume. Like Ceylon cinnamon, it is collected both from wild and from cultivated trees, mostly the latter. It comes from Southern China, and is therefore often called Chinese cinnamon. The name is a bad one, however, as it does not distinguish it from No. 3. The trees are cut down when about six years old, and the long straight

shoots, about an inch in thickness, are peeled in lengths of about a foot. Each quill is usually the bark from half the circumference. The outer bark is not carefully scraped away as in the last, but is roughly and imperfectly shaved off with an instrument resembling a spoke shave. The quills are dried and packed separately. The description of this species is as follows: "In quills of varying length and about 1 mm. or more in thickness; nearly deprived of the corky layer; yellowish brown; outer surface somewhat rough; fracture nearly smooth; odor fragrant; taste sweet and warmly aromatic." This variety tends much more to bitterness and astringency than the last. Its better grades also contain more sugar and gum. Its yield of oil is ordinarily less, and this is usually not quite so fine, though it is the ordinary commercial sort. The special feature of this cinnamon is its variability. Its best varieties are rather sweeter than the last in flavoring, but the taste does not endure so well. Its poorer varieties are scarcely fit for use. The best varieties are the "Java" and "Batavian." They are very carefully prepared from young shoots. The outer bark is entirely removed, the color is a pale yellow-brown, the taste fragrant, sweet, and very mucilaginous. The latter character rather disqualifies it for pharmaceutical uses, but makes it better, if anything, for culinary purposes. The poorest grades are the cheap "Chinese Mats." In preparing them, each packer has three lots of material to draw upon. First, some long quills of fair quality; second, some broken material and chips of very inferior grade; third, sand or other heavy foreign material. These he uses in regular proportions and packs neatly, with the good bark in a thin layer upon the outside. Two small rolls are sewn into a mat. Cassia is the cinnamon almost exclusively used in the household, and the most of this is of the poorer grades, besides which the ground article is enormously adulterated.

SAIGON CINNAMON, CINNAMOMUM SAIGONICUM, "GOD'S CINNAMON."—To this variety also the name *Chinese Cinnamon* is applied. "The bark of an undetermined species of Cinnamomum" (U. S. P.). We are entirely ignorant of the botanical origin of this variety. Although it has frequently been assumed that it is from the same plant which yields the last, its characters almost certainly prove the contrary. For many years we heard of a cinnamon in the unvisited regions of Southern China which was unknown in civilization, and of wondrously fine quality. Its curative properties were almost deified by the Chinese. At length some small lots were brought out, and it has now become a regular article of commerce. Little is known of the methods of its collection or drying. It comes in single quills of a foot in length, none of the outer bark being removed. These are tied neatly in bundles about ten inches in diameter. Each case contains rolls made up of bark of different respective thickness, the intermediate being the best. The thinnest is smoothish and of a dark red-brown. The others are gray or gray-brown and rough, the intermediate granular, the thickest fissured. Saigon cinnamon sometimes comes in chips of very thick bark, sometimes a third to a half inch thick. At its best, this entire thickness is free from astringency and bitterness, fragrant and very sweet, differing markedly in this character of the outer layers from either of the others. It is also peculiar in its sugary sweetness. Its aromatic property also is quite distinct, being biting rather than mild. Altogether, it is the sweetest and strongest of the cinnamons, but at the same time the least permanent as to flavor and odor. It is clearly nearer to cassia than to Ceylon cinnamon. Its best grade is much the most expensive variety of cinnamon. It is subject to substitution by a false article, very closely resembling it, both naturally and in its packing. This article is a cinnamon, and looks as though it might be selected from unpeeled cassia. The intermediate size is that adopted by the Pharmacopœia, and is thus described:

"In quills about 15 cm. long, and 10 to 15 mm. in diameter, the bark 2 or 3 mm. thick; outer surface gray or light grayish brown with whitish patches, more or less rough from numerous warts and some transverse ridges and fine longitudinal wrinkles; the inner surface cinnamon-brown or dark brown, granular and slightly striate; fracture short, granular, in the outer layer cinnamon-colored, and near the cork with numerous whitish striæ forming an almost uninterrupted line; odor fragrant; taste sweet, warmly aromatic, somewhat astringent."

Some other cinnamon species and products, including the oil of cinnamon, will be discussed at the close of the article.

Composition.—The general composition of the bark has already been given. The only constituent that can by any reasoning be classed as medicinally active is the oil, which exists in the proportion of one-half to one and one-half per cent.

Action and Uses.—Aside from its use as a condiment, and as an adjuvant in the pharmacy, its properties and uses are entirely those specified under the title of the oil.

Preparation.—The only medicinal preparation, strictly speaking, other than those of the oil, is the ten-per-cent. tincture, made from the Ceylon variety, the dose being 4 to 8 c.c. (fl. ʒ i.–ij.). The dose of powdered cinnamon of any variety is 0.5 to 2 gm. (gr. viij.–xxx.). Ceylon cinnamon enters into the aromatic powder, and cassia into the compound tinctures of cardamom, catechu, and lavender, but none of these are proper preparations of cinnamon as such. Saigon cinnamon enters into no preparation.

Cassia Chips.—These are the trimmings of cassia bark which cannot be utilized as cinnamon, but which yield a certain amount of oil upon distillation.

Cassia Buds or Cassia Flowers are the unripe fruits, not only of the species above named, but also of *C. Tamala* Nees ab Eberm. and *C. dulce* N. ab E. *C. daphnoides* Sieb. and Zucc. and *C. Loureirii* Nees yield a very poor quality of a false cinnamon. The leaves of *C. obtusifolium* Nees, *C. iners* Reinw., *C. nitidum* Hook., *C. Tamala* N. ab E., and some other species have been articles of commerce under the name of Malabathrum leaves. The bark of various species have found minor uses in medicine, chiefly as anti-diarrhœal agents, acting partly by their tannin and partly by the volatile oil.

Henry H. Rusby.

CINNAMON, OIL OF.—OLEUM CINNAMOMI. The origin of this oil has been sufficiently explained. Our Pharmacopœia directs that it be distilled from cassia cinnamon, not because that of Ceylon cinnamon is unsatisfactory, but because the two, if first class, are hardly to be distinguished, and practically all of the oil of commerce comes from cassia. Much of the commercial oil is said to be distilled from the leaves. While ordinary oil of cinnamon can be had for two or three dollars a pound, that of the Ceylon brings twenty, and is no better. The following is its official description:

"A yellowish or brownish liquid, becoming darker and thicker by age and exposure to the air, having the characteristic odor of cinnamon, and a sweetish, spicy, and burning taste. Specific gravity, 1.055 to 1.065 at 15° C. (59° F.). Soluble in an equal volume of alcohol, the solution being slightly acid to litmus paper; also soluble in an equal volume of glacial acetic acid. When shaken with a saturated solution of sodium bisulphite, it solidifies to a crystalline mass. If four drops of the oil, contained in a test tube, be cooled to 0° C. (32° F.), and then shaken with four drops of fuming nitric acid, crystalline needles or plates will be formed. If a portion of the oil be shaken with water, and the liquid passed through a wet filter, the clear filtrate should give, with a few drops of basic lead acetate T. S., a white turbidity, without a yellow color (absence of oil of cloves). If four drops of the oil be dissolved in 10 c.c. of alcohol, the subsequent addition of a drop of ferric chloride T. S. should produce a brown, but not a green or blue, color (absence of oil of cloves or of carbolic acid). If 1 c.c. of the oil be mixed with 3 c.c. of a mixture of three volumes of alcohol and one volume of water, a clear solution should result; and if to this solution there be gradually added 2 c.c. of a saturated solution of lead acetate in a mixture of three volumes of alcohol and one volume of water, no precipitate should be produced (absence of petroleum, or of colophony)."

The active constituent of this oil is *cinnamic aldehyde.* It should contain not less than seventy-five per cent. of it, and eighty-five per cent. is easily attainable. Since the relative values of different samples are exactly proportional to the percentage of this substance, and since the latter can be purchased and its purity readily determined, a great gain would be made by using it instead of the oil. It is readily oxidized into cinnamic acid. Oil of cinnamon possesses the ordinary properties of volatile oils (see *Active Constituents of Plants*) and is peculiar among them because of its being generally regarded as the most agreeable, and because it is probably the most highly antiseptic of them all. The dose is ♏ i. to v. We have two official preparations, the water, strength one-fifth of one per cent. and dose 15 to 30 c.c. (℥ ss.–i.), and the spirit, strength ten per cent. and dose 0.5 to 2 c.c. (8 to 30 m.).

Henry H. Rusby.

CINNAMYL-META-CRESOL. See *Hetocresol.*

CIRCULATION OF THE BLOOD.—I. COMPARATIVE AND HISTORICAL INTRODUCTION.—The term circulation as applied to the blood was first used in physiology by Cesalpino (1569) to describe the true path taken by it in its passage from the right to the left side of the heart. The Galenic doctrine, according to which this passage was made by way of pores in the intraventricular septum, was accepted without question until Servetus (1553) and Vesalius (1555) established anatomically the soundness and impermeability of the septum of the heart. The idea of the actual path by way of the pulmonary vessels seems to have suggested itself immediately, this course being correctly described in the writings of Servetus and Columbo (1559); and although a pure surmise from the logical necessities of the case and unsupported by experimental proof, it quickly gained acceptance and was named "circulation."

By extension the term has come to be applied to the motion of the blood in animals generally, however irregular and variable this may be. The comparative physiologist speaks of the circulation of the blood even in those invertebrate animals in which neither heart nor vessels exist, and in which a sluggish ebb and flow of the blood through irregular tissue spaces and perivisceral cavities alone occurs, the movement being the result of contractions of the alimentary canal and the body generally. Etymologically the word circulation would be applicable only to the conditions found in the fishes, birds, and mammals. The accompanying diagrams of the vascular systems of the crayfish, fish, frog, and mammal will serve to illustrate some of the fundamental differences found in the animal series in respect to these organs.

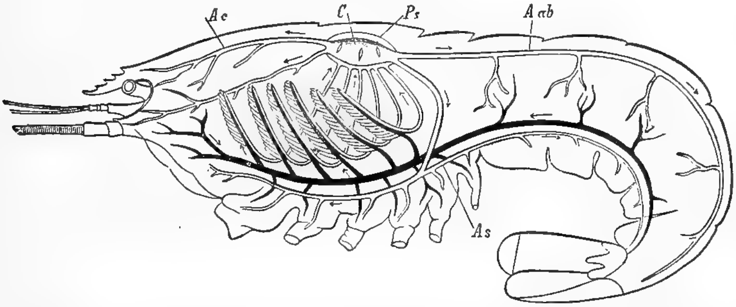

FIG. 1325.—Heart and Blood-Vessels and Gills of the Crayfish. *c*, Heart in a blood sinus, with *Ps*, several pairs of ostia; *Ac*, cephalic aorta; *A.ab*, abdominal aorta; *As*, sternal artery.

As to the invertebrate type, represented here by the crayfish, two distinguishing peculiarities are to be noted. In the first place, the heart and blood-vessels do not form a closed system of channels. However highly developed the vascular system in them may be, it will be found that in some part or parts of the body the vessels terminate and the blood flows into so-called "lacunæ" or tissue spaces not bounded by any limiting membrane. This condition obliterates the distinction between blood and lymph and leads to the use of such terms as "hydrolymph" and "hæmolymph" for the blood of these animals. The other characteristic feature consists in the fact that the blood returns to the heart from the respiratory apparatus where one is present, instead of from the body generally, constituting a so-called "arterial heart."

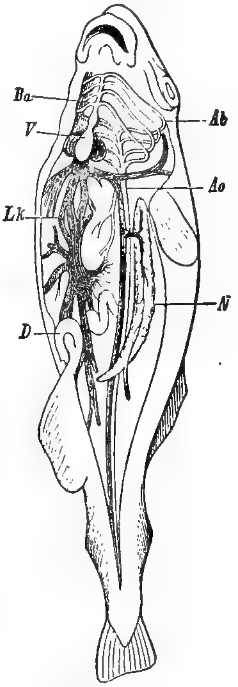

FIG. 1326.—Diagram of the Circulatory Organs of an Osseous Fish. *V*, Ventricle; *Ba*, aortic bulb, with the arterial arches which carry the venous blood to the gills; *Ao*, dorsal aorta, into which open the vessels from the gills or branchial veins, *Ab*; *N*, kidney; *D*, alimentary canal; *Lk*, portal circulation.

Compare in both these respects the diagrams of the circulation of the lobster (Fig. 1325) and fish (Fig. 1326). In the latter the system of vessels is a closed one, and the heart functions as a venous organ. In the air-breathing vertebrates further changes in the circulatory organs accompany the appearance of pulmonary respiration. The tubular heart of the fish, with its four consecutive chambers, is replaced by an organ with a median partition. In the frog (Fig. 1327) the right and left auricles are completely separated in this way, while the ventricle remains a single chamber. A partial ventricular septum of increasing proportions is found in the turtles, snakes, and lizards, becoming complete only in the highest of the reptilia, the crocodiles, as it is in birds and mammals.

The above variations in the structure of the heart are attended by certain changes in the arrangement and connections of the main vessels arising from it, especially as regards the extent of the communication between the aortic and pulmonary arteries. The result of both series of changes is to secure an increasing amount of separation between venous and arterial blood. The venous blood of the right auricle in frogs mingles rather freely with the arterial blood of the left auricle when they reach the common ventricle. This occurs, to a diminishing extent, as the interventricular septum develops; but even in the crocodilia, in which it is complete, the mixing of the two kinds of blood is not wholly avoided, since there remains a communication—the foramen of Panuzzi—between the right and left aortic arches.

In birds and mammals the motion of the blood again becomes a true circulation, and a particle of it starting at any point of the system must make a complete circuit before it passes that point again. Accomplishing this it will traverse at least two capillary networks, the systemic and the respiratory, as was the case in fish also; but besides, it passes twice through the heart, in this respect differing from the fishes. The venous heart of the latter has been replaced by a double organ with a right venous side which transfers the blood from the systemic veins to the pulmonary arteries; and a left arterial side, which returns it again from the pulmonary veins to the aorta, each half being further subdivided into an auricular and a ventricular chamber.

A third set of capillaries may be interpolated in the course of a single circuit. Thus, the blood which supplies the stomach, intestines, pancreas, and spleen is collected in the portal vein and must pass through the capillaries of the liver before it can reach the heart. This constitutes what is known as the "portal or the hepatic portal circulation," and the arrangement is universal among all the vertebrates. An analogous condition is found in the "renal portal circulation" of the reptiles, amphibia, and fish.

The perpetual motion of the blood in a circle through the heart, arteries, and veins was discovered by William Harvey in 1616. Guided by the important anatomical discoveries of the preceding century, the true significance and import of which he first correctly appreciated, the illustrious Harvey succeeded by a series of wisely planned and skilfully executed experiments in overcoming the prevailing misconceptions and in giving us an account of the circulation which in all its general features remains substantially correct after the lapse of more than three centuries. Beginning with the heart, he studied both the rhythm and the sequence of its beat, and emphasized the fact that the systole constituted the active phase while the diastole was passive. He noted the beginning of the beat in the auricles, which contracting together, discharge their contents into the ventricles; that these then follow with their contraction, the right ventricle driving the blood into the pulmonary artery, the left ventricle into the aorta. The lesser circulation through the lungs having been described before, Harvey could only confirm this fact by new evidence from comparative anatomy and embryology. His essential contribution consisted in tracing the fate of the blood pumped into the aorta, and showing that this travelled peripherally in the arteries, was transferred somehow to the veins, and in them was carried in a centripetal direction back to the right auricle. The nature of the connection between the arteries and veins at the periphery Harvey was unable to make out, although the fact of its existence was indisputably established. This last link which was needed to complete the circuit came with the discovery of the capillaries by Malpighi (1661), four years after Harvey's death.

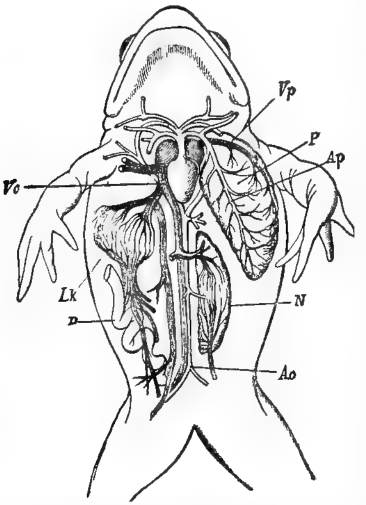

FIG. 1327.—Circulatory Organs of the Frog. *P*, Left lung—right lung is removed; *Ap*, pulmonary artery; *Vp*, pulmonary vein; *Vc*, vena cava inferior; *Ao*, dorsal aorta; *N*, kidney; *D*, alimentary canal; *Lk*, portal circulation.

Confirmation of the work of Harvey soon accumulated from various sources. Leeuwenhoek (1669) saw the circulation of the blood in the vessels of the bat's wing, the tail of the tadpole, and the fins of fishes. About the same time the methods of injection were carried to a high degree of perfection, so that Swammerdam and Ruysch by this means also demonstrated the continuity of the arteries and veins at the periphery. Our knowledge of the circulation has been extended and perfected since that time in many directions. Some of the more notable advances include the discovery of the lacteals (Asselli, 1662) and lymphatics, of the cardiac (E. H. and E. F. Weber, 1845; von Bezold, 1860–1866; M. and E. Cyon, 1866; Schmiedeberg, 1870) and vaso-motor nerves (Cl. Bernard, 1849) and the introduction and application of the graphic method to the study of the movements of the heart and blood-vessels (Ludwig, Marey, etc., etc.).

II. MECHANICS OF THE CIRCULATION.—The closed system of channels through which the blood circulates includes the heart, arteries, capillaries, and veins. The first of these is essentially a muscular force pump whose rhythmical strokes at the rate of about 72 per minute drive the blood through the vessels in a constant direction with a considerable velocity. Before taking up the action of the central pump, it will be convenient to note the general features of this blood current.

Its study is essentially a physical problem in hydrodynamics whose complete theoretical treatment is rendered practically impossible by the complex arrangement and mode of branching of the vessels, by the constant change in the physical properties of their walls along their length, and by the continual interaction of their physiological activities. An account of the mechanics of the flow in the vessels must be based mainly on empirical data, and the fundamental laws of hydrodynamics which are here introduced are intended merely to assist in the interpretation of these data.

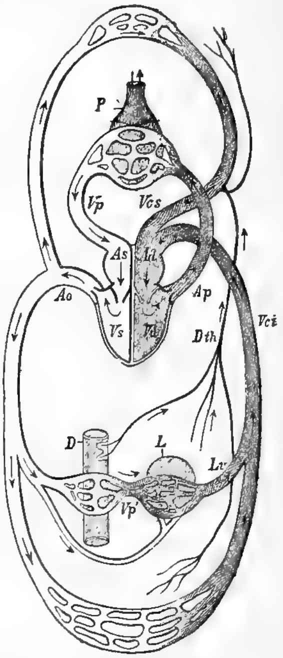

FIG. 1328.—Diagram of the Circulation in an Animal with a Completely Separated Right and Left Ventricle and a Double Circulation. (After Huxley.) *Ad*, Right auricle receiving the superior and inferior venæ cavæ, *Vcs* and *Vci*; *Dth*, thoracic duct, the main trunk of the lymphatic system; *Ad*, right auricle; *Vd*, right ventricle; *Ap*, pulmonary artery; *P*, lung; *Vp*, pulmonary vein; *As*, left auricle; *Vs*, left ventricle; *Ao*, aorta; *D*, intestine; *L*, liver; *Vp*, portal vein; *Lv*, hepatic vein.

A. *The Flow of Liquids in Rigid and Elastic Tubes.*—Torricelli's theorem states that when water escapes from an aperture in the side of a reservoir filled to a constant level, the velocity of outflow theoretically is given by the formula $V = \sqrt{2gH}$, in which g equals the acceleration of falling bodies produced by gravity and H equals the height of the column of liquid above the aperture. The actual velocity is obtained by dividing the amount which

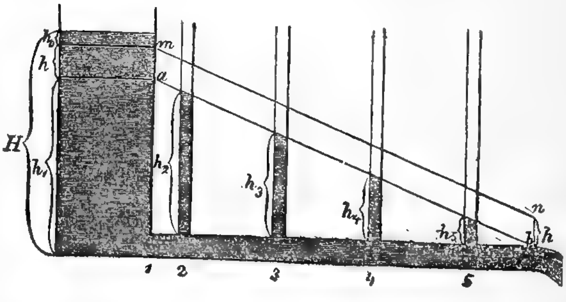

FIG. 1329.—Diagram Illustrating the Flow of Liquids in a Horizontal Rigid Tube of Uniform Calibre, when connected with a reservoir. (From Rollett.)

flows out in a unit of time by the cross section of the aperture, and experiment shows that this is less than the theoretical value. A part of the energy of position represented by the column of liquid H is lost at the aperture through the mutual interference of the particles of water as they approach the opening from different directions, the result of which is the so-called "contractio venæ" near the beginning of the jet. If the lost fraction of the total energy be represented by a column of liquid equal to h_0, and the energy spent in giving velocity by h, then the total height $H = h_0 + h$. Now suppose a horizontal, rigid tube of some length attached to the aperture in the reservoir (see Fig. 1329). The velocity of outflow from the end of the tube can again be calculated from the volume of outflow and the cross section of the tube; then by substituting this value of v in the formula $v = \sqrt{2gH}$, it will be found that h, the portion of the total energy of position H that is available for velocity, is less than in the case of the free aperture. A second portion of H has been consumed in overcoming the resistance in the tube. Call this part h_1, then $H = h_0 + h + h_1$.

When liquids wet the sides of the tube through which they are flowing, the layer of particles next the wall of the tube may be considered practically at rest on account of adhesion. The layer next within moves along slowly, the next a little faster, etc., the velocity increasing with each successive layer to the axis of the tube, where it reaches a maximum. By the velocity of the whole stream as calculated for the tube above is meant the mean or average velocity of all the layers, and it has been shown that when the bore of the tube falls within certain limits so that the movement of each particle of liquid is parallel to the axis, this mean velocity equals one-half the axial or maximal velocity.

The resistance to the flow of liquids in tubes thus appears as a case of internal friction, as if the whole column of liquid were made up of a series of concentric cylinders, each moving a little faster than the next larger, and the outermost one completely at rest against the sides of the tube. This internal friction constitutes a resistance which retards the flow and puts the liquid under tension felt as lateral pressure against the walls. Gauges arranged along the tube (h_2, h_3, h_4, h_5, Fig. 1329) to indicate this pressure show that at each point it is proportional to the amount of resistance beyond and that it becomes zero at the free outlet. In tubes of uniform calibre the lateral pressure drops uniformly; but where narrower and wider sections alternate, the fall is irregular for obvious reasons.

Liquids being incompressible, the amount of fluid passing each cross section anywhere along the tube in a second must be the same; the rate of flow, therefore, at each point will be inversely proportional to the width of the tube. The more rapid flow and consequent increase of internal friction in the narrow portions make heavier draughts on the store of available energy, and the lateral pressure falls more quickly here than in the wider portion.

In a system of tubes like the blood-vessels, in which the main channel subdivides dichotomously into numerous smaller branches whose total sectional area far exceeds that of the original trunk and in which these branches are gathered again into a single small tube, the velocity is determined by the same law of inverse proportion to the width of the bed, and is therefore slowest in the smaller tubes where the total area is greatest. On account of the slowness of the current, the pressure should fall slowly in this region; but the increase of surface in the numerous narrow channels operates the other way, so that the actual rate of fall in the pressure will depend on the relative magnitude of these two opposing factors.

As regards the nature of the tube, the same laws apply with equal force whether the walls are rigid or elastic provided only the flow is continuous and uniform. When, instead of the steady, continuous pressure of a column of liquid, an intermittent force is used to drive the liquid into the tube, the character of the wall makes its influence felt. The capacity of a rigid tube being invariable, the inflow and outflow must be synchronous and equal in amount; an intermittent charge necessarily implies an intermittent discharge. An elastic tube when short and wide behaves in the same way; but if from increase of length or constriction at the outlet resistance arises, the outflow no longer corresponds in time to the inflow. The injected liquid is partly retained by the tube, whose walls yield to the distending force of the lateral pressure, and is discharged only in the succeeding interval by their elastic recoil.

If the intermittent influx is rhythmically repeated at sufficiently short intervals, each new charge arriving before the previous one has been displaced, the outflow becomes continuous. By properly adjusting the resistance in the tube to the force, rate, and stroke of the pump, an elastic tube can be made to convert a rhythmic intermittent current into a continuous even stream, just as the elastic air cushion does in the ordinary fire engine.

B. *The Blood Flow in the Vessels.*—1. General Account of the Vascular System. The arteries and veins physiologically are merely conducting channels to and from the capillaries, which alone are fitted by the structure of their walls to bring the blood into nutritive relation with the tissues and enable it to fulfil the function of an internal medium. The arteries possess stout walls which are both elastic and contractile. Their elasticity is slight but perfect, yielding readily to a distending force, but returning to their original size as soon as the distending force is removed. As in skeletal muscle, the coefficient of elasticity is not constant; it increases with the load, and the curve of extensibility is approximately an hyperbola. The result is that the distention of the arteries under the influence of a rising blood pressure soon approaches the point where any further increase of size requires a disproportionately great rise of pressure. The cohesion of the vessel walls is also considerable and capable of withstanding many times the strain normally put upon them in the body. The carotid of the sheep, for example, is ruptured only when fourteen times the usual pressure it is called upon to bear is put upon it, and the human carotid resists a pressure of eight atmospheres. The relative proportion of muscular and elastic tissue varies in different arteries, the elastic tissue predominating in the larger arteries near the heart, while the smaller ones nearer the periphery are eminently muscular and contractile. It appears from the data available up to this time that for a given rise of pressure the distensibility of the arteries increases with their distance from the heart. These physical properties evidently adapt the arteries to the work of converting the intermittent discharges of the heart into a continuous and steady flow in the capillaries and of regulating the distribution of the blood according to the needs of the several organs. As they leave the heart the arteries continually break up into smaller branches until they terminate in the capillaries. At each point of bifurcation the resulting branches individually are smaller than the parent vessel, but taken together their area is greater. Hence the sectional area of the arterial bed increases steadily toward the capillaries, the total cross section of which is several hundred times that of the aorta.

The capillaries with their delicate endothelial walls are elastic, and yield readily to changes of internal pressure. This alone would account for the observed variation in the size of their lumen within the wide limits of 5 to 20 μ; but in addition they are believed to possess the power of active contractility. The veins have thin walls in which white fibrous tissue predominates, but in which some elastic and muscular elements also occur. Their curve of extensibility is similar to that of the arteries, while their cohesion is even greater. Given a vein and an artery of the same thickness, a greater pressure is required to rupture the former than the latter. The elasticity and contractility of the veins serve mainly to adapt the capacity of the whole vascular system to variations in the quantity of blood, and thus to regulate the filling of the heart in diastole. The cross section of the bed again diminishes in the veins in passing from the capillaries to the heart; but since the venæ cavæ together have nearly twice the area of the aorta, the total capacity of the veins far exceeds that of the arteries. The veins, in fact, can easily hold the total blood of the body, as is practically the case after death when the arteries are empty, and in the paradoxical experiment of bleeding an animal to death into its own veins.

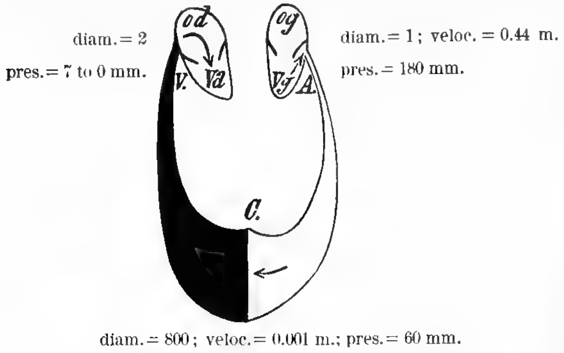
od
og
diam. = 2
pres. = 7 to 0 mm.
diam. = 1; veloc. = 0.44 m.
pres. = 180 mm.
V.
Vd
Vg
A.
C.
diam. = 800; veloc. = 0.001 m.; pres. = 60 mm.

FIG. 1330.—Schema of the Major Circulation. *AC*, Arterial cone; *CV*, venous cone; *C*, capillary expanse.

2. The Blood Pressure. Familiar experiences of daily life have long since made some of the differences between the character of the current in the arteries and in the veins a matter of common knowledge. The arteries present to the finger a sense of resistance which increases rhythmically at each heart beat and expands their walls —producing the so-called "pulse." When an artery is severed, the blood spurts from its central end with considerable force, the jet being continuous but not equable. Finally when an artery is ligated, it swells on the proximal side, while on the distal side the pulse disappears and its walls collapse. Compare with all this the behavior of the veins; they are soft and easily compressed; there is no pulse; the blood issues in a gentle, continuous stream from the distal cut end, and a ligature distends them on the peripheral side. These facts demonstrate a difference not only in the direction of the current in the two kinds of vessels, but also in the tension or internal pressure.

Stephan Hales first measured the pressure in the arteries of living animals (1733). His method was to connect the central end of an artery with a vertical tube and to read off the height to which the blood rose. Owing to the error from loss of blood and to inconvenience from frequent clotting in the tube, the original method is not suited for prolonged and accurate observations. The mercury manometer was substituted by Poiseuille (1828) to meet these difficulties, and this instrument, with a float and writing style added, marks the beginning of the use of the graphic method in physiology. The mercury manometer satisfies the requirements in all cases involving questions of mean blood pressure and remains in general use for this purpose. On account of its great inertia, however, it cannot record with accuracy the finer shades of variations, especially when sudden and extensive, like those produced by the systole and diastole of the heart. Various forms of spring manometers have been devised to register these changes of pressure, some of them having developed the capacity of responding accurately to a change of 10,000 mm. of mercury per second.

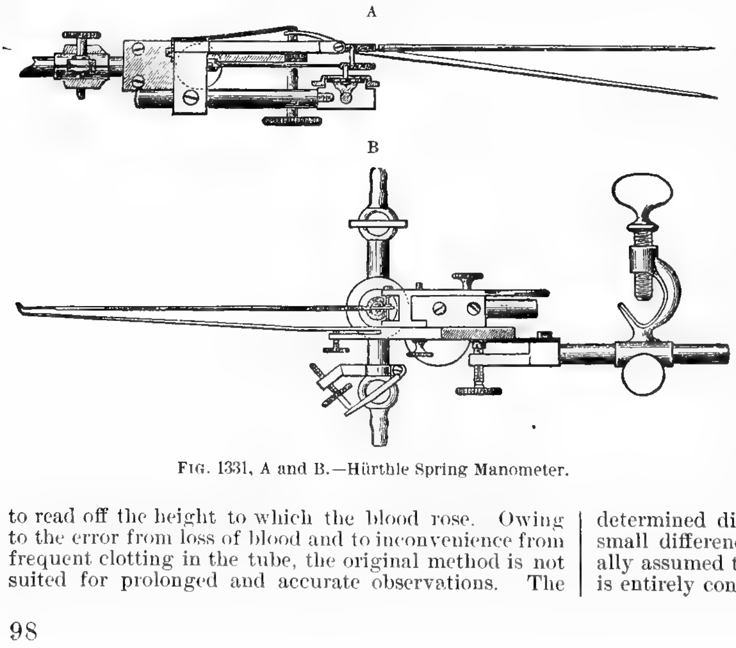

FIG. 1331, A and B.—Hürthle Spring Manometer.

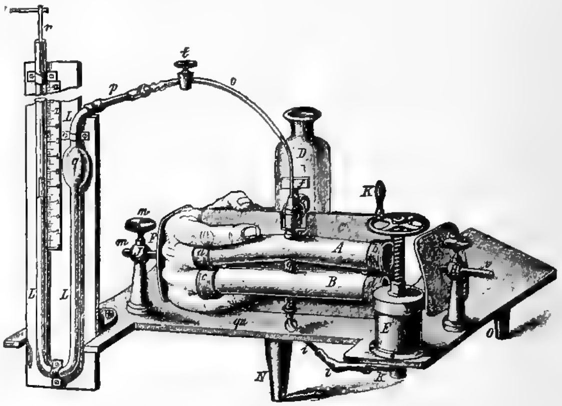

FIG. 1332.—Sphygmomanometer of Mosso.

These methods are rarely applicable to man as they require vivisection, and special devices had to be invented to obtain records of the blood pressure in human beings. Among these the sphygmomanometer of von Basch has been found of some practical value by clinicians. The instrument in reality determines the pressure required to obliterate the pulse beyond the point of application, and gives therefore only an approximate idea of the blood pressure; it can, moreover, be used only on superficial arteries whose position provides for a firm background. While the absolute values which it gives are unreliable, the limits of error extending from 32 to 78 mm. Hg (Tigerstedt), it is fairly well adapted for obtaining relative values for a given individual and within certain time limits.

More recently Hill[1] and Mosso[2] have constructed instruments which promise better results. They are based on the principle that the amplitude of the pulse oscillations is greatest when the blood pressure on the inside of an artery is exactly balanced by pressure from without. These instruments also have their practical limitations, but valuable data are confidently expected to accumulate when they become more widely known.

Direct measurement by one or another of the methods enumerated above shows that: First, the mean blood pressure is highest in the aorta, and that it diminishes along the arterial tract from the heart toward the capillaries. For example, aortic pressure in the dog = 130 to 180 mm. Hg; rabbit = 100 to 130 mm. Hg; horse = 150 to 200 mm. Hg.

In man the aortic pressure cannot be determined directly; but in view of the comparatively small differences among mammals of all sizes, it is usually assumed to be about 150 mm. Hg, an estimate which is entirely consistent with the results obtained on more peripheral arteries as given by various observers. Thus Albert[3] found the pressure, in the tibial artery of a boy, 100–160; von Basch,[4] in the radial of man, 135–165; Faivre,[5] in the brachial of man, 110–120; Hill,[1] in the brachial of man, 100–120; and Mosso,[2] in the digital artery of man, 100.

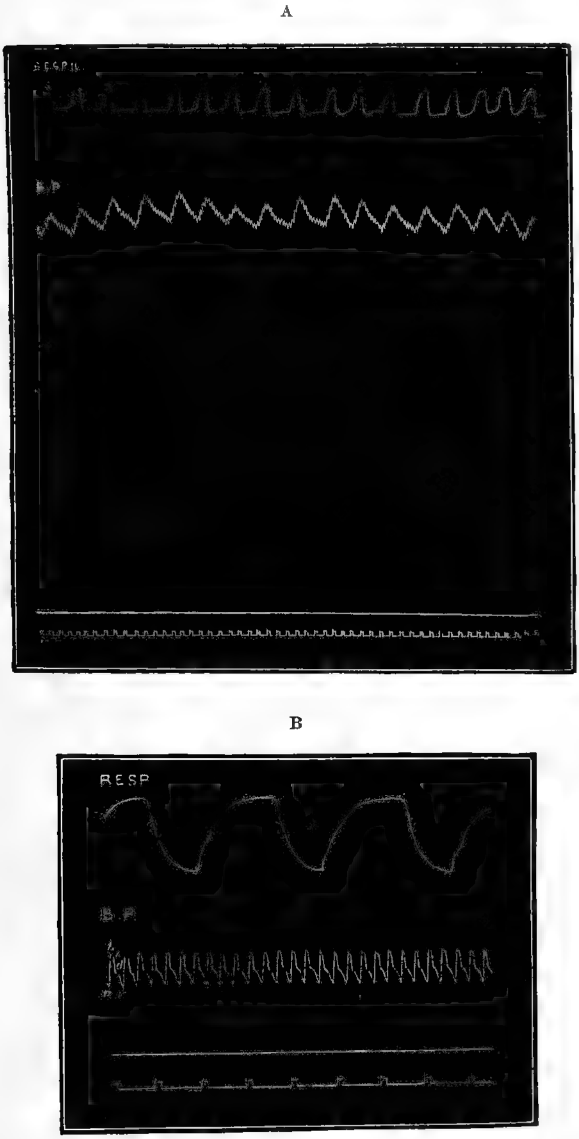

FIG. 1333, A.—Tracing of the Blood Pressure from a Rabbit Taken by the Mercury Manometer. *B.P.*, Curve of blood pressure. The horizontal line at the base shows the position of the zero pressure. Time tracing in seconds. B.—Normal Blood-Pressure Record Taken from the Rabbit with a Hürthle Manometer. The horizontal line again shows the position of the zero pressure. Time in seconds.

The pressure in the arteries shows, moreover, rhythmic oscillations synchronous with the systole of the heart. The relative extent of these variations as compared with the mean blood pressure was recognized only after the introduction of spring manometers, as the inertia of the mercury largely damped the individual beats. Compare, for example, the following records:

In the aorta of a rabbit Hürthle found the difference between diastolic and systolic pressure to equal 40 to 50 mm. Hg, *i.e.*, about one-third the total mean pressure. These oscillations diminish in amplitude as the distance from the heart increases, and disappear altogether in the capillaries and veins under ordinary circumstances.

Secondly, the mean pressure is low in the veins throughout, but higher in the small veins, gradually becoming less toward the heart; in the external jugular and similar vessels close to the heart it may even fall below zero.

Thus, in the sheep the following figures have been obtained: Pressure in the external facial vein, 3 mm. Hg; pressure in the brachial, 4 mm. Hg; branches of brachial, 9 mm. Hg; crural vein, 11.4 mm. Hg.

The pressure in the capillaries must be determined by indirect methods. Valuable indications of changes of pressure within them are gained from simultaneous records of the pressures in the corresponding artery and vein. To obtain a measure of the absolute capillary pressure von Kries applied pressure to the skin or mucous surface and determined the weight necessary to produce a visible change of color (blanching), which was taken to mean collapse of the capillaries. The result, which he places at 33 mm. Hg for the rabbit's gum, is regarded as a rough approximation, but it is sufficient to indicate that the capillary pressure is intermediate between that of the arteries and veins respectively.

There is consequently a continuous though irregular decline of pressure from the aorta to the right auricle. The fall is slow and gradual in the arteries and veins, but between the small arteries and small veins, *i.e.*, in the region of the arterioles, capillaries, and venules, it is marked and sudden. The curve of pressure would, therefore, have some such form as that represented in Fig. 1334.

The circulation in the peripheral region, where the greatest changes obviously take place, can be directly observed in transparent organs with a microscope. The blood is there seen to pass in a continuous stream from the small arteries through the capillaries, to the veins. The velocity is greater in the arteries than in the veins, and greater in both than in the capillaries. Faint pulsations synchronous with the heart's beat are also visible in the arteries, but these disappear in the capillaries and veins. In the small capillaries the corpuscles are pressed through in single file and occupy the whole bore, but in larger capillaries, and especially in the small arteries and veins which permit the passage of more than one corpuscle abreast, the red corpuscles run in the middle of the channel, forming a colored core, while a colorless layer of transparent plasma is left between it and the sides of the vessel. These are known respectively as the "axial current" and the "peripheral zone," or "Poiseuille's space."

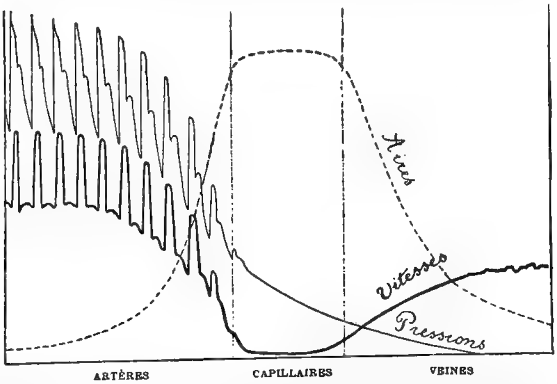

FIG. 1334.—Schematic Representation of the Variations of Pressure, Velocity, and Sectional Area of the Different Parts of the Circulatory System. (Modified from Gad.)

In the plasmatic layer white corpuscles are frequently seen clinging to the sides of the vessel, sometimes rolling slowly along, and in general having an irregular motion with frequent temporary stops. In all cases the blood as it passes through the capillary stretches and expands the walls, and the flow is subject to many variations.

Rarely are the capillaries equally distended throughout a given field, and frequently the corpuscles will appear to remain stationary in one or more of them for a brief period and then to move on again. The whole picture manifestly shows that the passage through the capillaries is attended with considerable difficulty. The resistance to the flow of the blood caused by friction is small in the large arteries; it increases gradually as they divide, but receives its chief and most important addition in the minute arteries and capillaries, especially in the former, on account of the flow being more rapid in them. This constitutes what is so frequently referred to as the "peripheral resistance" and is one of the important physical factors in explaining the circulation.

The high pressure and pulsatile flow in the arteries, the steady stream through the capillaries, and the low pressure and uniform flow in the veins can all be explained on purely physical principles. In the systole of the ventricle (1), driving a certain quantity of blood into the aorta at regular intervals and with a certain force; the long stretch of elastic branching arteries (2), and the peripheral resistance (3) are provided all the conditions which were shown above to be necessary for the conversion of an intermittent into a continuous current, while the veins afford a free and easy passage for the blood back to the heart when the greater part of the energy imparted by it to the blood has been expended in passing the peripheral resistance. The circulation in the vessels at any moment represents a state of dynamic equilibrium which is subject to constant variations. The energy of the heart's action may be altered by variations in the rate, volume, and force of its strokes. Again, the peripheral resistance may vary in consequence of changes in the calibre of the vessels. Constriction on their part over any considerable area will raise, widespread dilatation will lower, general arterial pressure.

Changes in both heart and arteries are constantly taking place, and indeed are necessary and essential. A fixed and rigid condition of the circulatory apparatus, devoid of adjustments within wide limits to adapt the blood flow to the varying needs of the several organs, would be worse than useless; it would be positively harmful. The mechanisms by which these changes are effected will be considered later on.

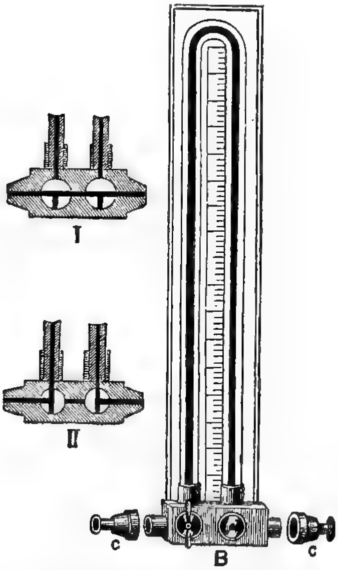

FIG. 1335. Volkmann's Hæmodromometer. I, Blood flows from artery to artery; II, blood must pass through the glass tube of B; c, c, cannulæ for the divided artery.

A third factor which may exert some influence on the blood pressure is the quantity of blood contained in the vessels. The amount normally present would be able, in a state of static equilibrium, the heart being at rest, to produce a uniform mean pressure of only 5 to 10 mm. Hg throughout the vascular system in dogs.[6] But during life the heart maintains a continuous circulation by accumulating the blood in the arteries under a positive pressure, thanks to the peripheral resistance and the elasticity of their walls, while the veins are emptied to a corresponding extent and the pressure within them reduced below the mean. Experimental investigation as to what would be the effect of increasing or diminishing the quantity of the circulating medium has shown that variations in both directions and within considerable limits have a surprisingly little effect on the arterial pressure, compensating mechanisms being provided for quickly restoring it to, and preserving it at, the normal level. These mechanisms are manifold and complex, and a brief enumeration is all that can be attempted here. Taking the case of a copious intravenous injection, say of defibrinated blood or normal saline solution, the increased volume of blood is first provided for by relaxation and dilatation of the vessels. The veins especially expand to accommodate the increasing mass, and when the infusion becomes large enough the main veins are seen to be overfilled and the liver becomes as hard as a board. By this means and by partial failure of the heart's action from overdistention of its cavities the blood pressure tends to remain at or near the normal. More permanent relief, however, is obtained by other means and with striking rapidity. Transudation into the tissues removes a part of the injected fluid from the vessels, while the secretory activity of the kidneys and intestinal mucosa is enormously heightened and thus disposes of another portion. The character of the injection naturally exercises a decided influence on the relative share of these several mechanisms in the total result. In the case of hemorrhage, of course, the reverse series of changes are noted. There is a more complete emptying of the heart at each systole, a general contraction of the vessels, a restricted secretion from the kidneys, salivary and other glands, and a rapid absorption of lymph into the vascular system.

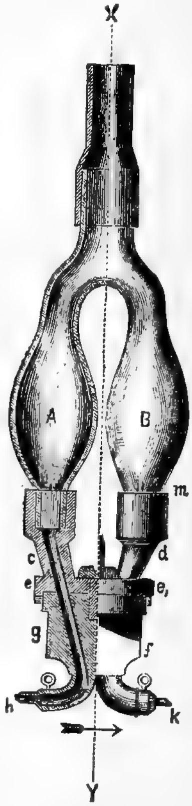

FIG. 1336.—Ludwig and Dogiel's Rheometer. X, Y, Axis of rotation; A, B, glass bulbs; h, k, cannulæ inserted in the divided artery, e, e, rotates on g, f; c, d, tubes.

In conclusion, two general facts in regard to the blood pressure deserve special mention: First, its remarkable constancy under ordinary circumstances in spite of many modifying influences; second, the important and extensive variations, seemingly out of all proportion to the exciting causes, occasionally produced by trifling and insignificant stimuli.

3. Velocity of the Blood Current. In considering the rate of flow in the vessels it is important to distinguish between the average velocity for a given period of time and the actual velocity which constantly oscillates above and below this mean with every phase of the heart's beat and with every variation of the peripheral resistance.

Volkmann first measured the mean velocity in the arteries in 1846 with his hæmodromometer.

The principle of the method is simply to determine the volume of blood flowing through an artery in a given period and dividing by its cross section. The quotient represents the length of a cylindrical column of blood with a base equal to that cross section, and therefore measures the average velocity in that time. Ludwig afterward devised a more convenient instrument, the stromuhr or rheometer, by means of which numerous data have been collected.

The results are not entirely exact, on account of many imperfections in the method, but they may be regarded as approximately true. Even in the course of a single experiment the mean velocity in the carotid or other large artery is found to vary considerably for reasons which will be stated presently. Disregarding these variations for the moment, the rate of flow in the carotid of the dog or horse, and probably also of man, may be placed at from 300 to 500 mm. per second. The rate diminishes in the smaller arteries the further one goes out from the heart, and becomes slowest in the capillaries. As measured in the web of a frog's foot under the microscope, it is about 0.5 mm. per second. There are reasons for supposing it somewhat greater in the capillaries of mammalia, where it has been estimated at about 0.8 mm. per second. On leaving the capillaries the flow is quite slow in the venous radicles emerging from them, but it increases as these join into larger trunks, until finally it attains a velocity approximately equal to one-half that with which it started in the aorta. These changes in the mean velocity along the system are determined according to one of the simple laws of hydrodynamics stated in the preceding section. A continuous circulation in a closed system implies that an equal quantity of fluid passes each cross section in a given time. Now the quantity which passes may be expressed as the product of the velocity by the cross section, thus $Q = V \times A$. And similarly $Q' = V' \times A'$, etc. But Q, Q', etc., being equal to one another $V \times A = V' \times A'$, hence $V : V' :: A' : A$, or the velocity varies inversely as the cross section along the system.

It was stated above that the arterial tree widens out steadily from the aorta to the capillaries (see Fig. 1330). Comparison of the respective velocities at these two points now shows that the amount of this increase must be something like five hundred times. For a graphic representation of the velocities in the vascular system and the relation to the sectional area see Fig. 1334 above.

This dependence of the velocity on the width of the bed applies of course only to the general rate of the whole system, and many special and transient variations constantly occur. Since the real cause of the flow from one point to another is the difference of pressure between those points, the actual velocity at each moment must depend on the amount of this difference of pressure and the resistance against which it is working. A change in either of these factors will necessarily affect the velocity. An illustration of this is found in the following observations on the rate of flow in the carotid of the dog by Dogiel:

Weight in kilograms.	Period of observation, in seconds.	Rate of flow in millimetres, varied.
23.3	80	From 733 to 349
12.1	127	" 520 " 243
3.2	63	" 458 " 411
3.6	45	" 339 " 204

The slowing of the current observed in each case is not referable to incipient coagulation or other experimental error, at least not to any great extent; on the contrary, it is due to changes in the condition of the peripheral area supplied by the carotid artery. Blood pressure remaining the same, the rate of flow becomes essentially a function of the peripheral resistance. The temporary interference with the circulation during the adjustment of the instrument destroys the tone of the vessels beyond, and lowers the resistance, so that the observed rate is at first too high. With circulation re-established the normal calibre is regained, the resistance increases, and a corresponding retardation is observed.

It will be noticed that this quickening influence of a local dilatation is in no sense a contradiction to the general principle that the rate of flow is inversely proportional to the width of the bed. The local change is not extensive enough to affect the total cross section of that level appreciably, but by reducing the resistance along one of numerous alternative paths increases the flow in that direction at the expense of the others. In such cases the flow of blood through the widened artery or arteries is for the time being increased in rapidity, not only in spite of, but actually in consequence of the artery being widened. The influence of changes in the blood pressure on the velocity is shown in the effect produced on the latter by each beat of the heart. When the velocity of flow is recorded by means of an instrument which will register its finer variations, say with the hæmodromograph of Chauveau and Lortet, at the same time that a pressure curve is taken with a spring manometer, the result shown in Fig. 1338 will be obtained.

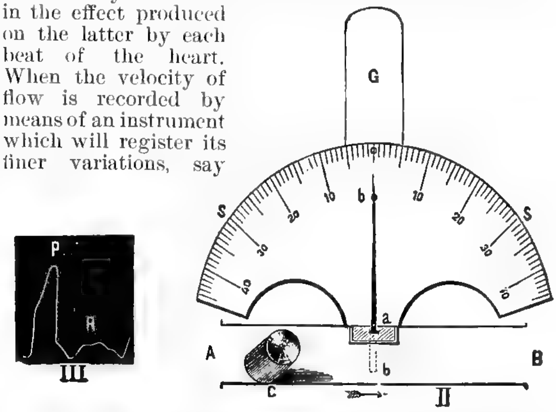

FIG. 1337.—II, Dromograph. A, B, Tube inserted in the artery; C, lateral tube connected with a manometer; *b*, index moving in a rubber membrane, *a*; G, handle. III, Curve obtained by dromograph.

The record shows a very marked acceleration during cardiac systole, the rate in the carotid of the horse rising to 520 mm. per second as compared with 150 mm. during diastole; and, indeed, the difference may be even greater than this after a general vaso-dilatation such as that following section of the spinal cord, when the diastolic rate falls extremely low.

The variations in the rate of flow in the arteries can be measured in man by an indirect method. When the volume of the arm is recorded by means of a plethysmograph, the changes which are observed are due to variations in the size of the arteries and indicate corresponding variations in the rate at which the blood enters them, the outflow from the veins being uniform. From the volume curve (see Fig. 1340) Fick constructed the curve of velocity, and found that it resembles closely the curve of Lortet obtained by the direct method on the horse.

4. The circulation in the veins is influenced by a number of accessory factors, whose combined effect renders it somewhat irregular perhaps, but which on the whole promote and quicken it. Among these secondary helps to the circulation the following are usually included, although the fact must not be lost sight of that the real cause of the venous flow is the ventricular stroke, enough of whose energy remains, after driving the blood past

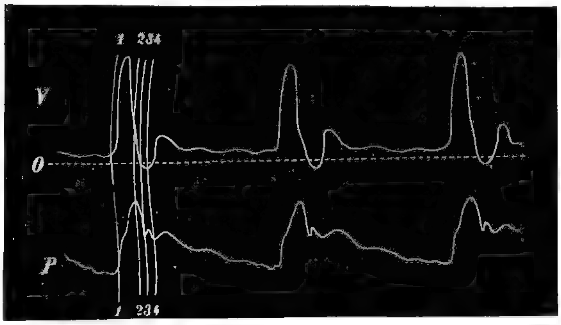

FIG. 1338.—Curves of Velocity (V) and Pressure (P) from the Carotid of the Horse. (According to Lortet.) The lines 1, 2, 3, 4 mark corresponding points in the two curves. The ventricular systole begins at 1; the diastole begins somewhere between 3 and 4.

the peripheral resistance, to carry it along the veins back to the heart.

a. Aspiration of the Thorax.—It has been stated above that the pressure in the great veins near the heart sinks below zero or atmospheric pressure. This is due to the permanent negative pressure in the thorax; and since every inspiration increases and every expiration diminishes the amount of this negative pressure, the breathing movements assisted by the arrangement of the valves constitute a virtual pump, which sucks the blood from the venæ cavæ and promotes the flow of blood in the direction of the normal circulation.

β. Contraction of the Skeletal Muscles.—Many of the veins possess valves which open freely toward the heart but effectually block the passage of the blood in the opposite direction. External pressure on such veins forces their contents along toward the heart while they fill again from the peripheral end when the pressure is removed. Something of this sort occurs in all bodily movements in which the muscles by their alternate contraction and relaxation provide the intermittent compression. It has been suggested that the pulsation of the arteries may similarly possess a mechanical function from the regular rhythmic shocks against the closely applied venæ comites.

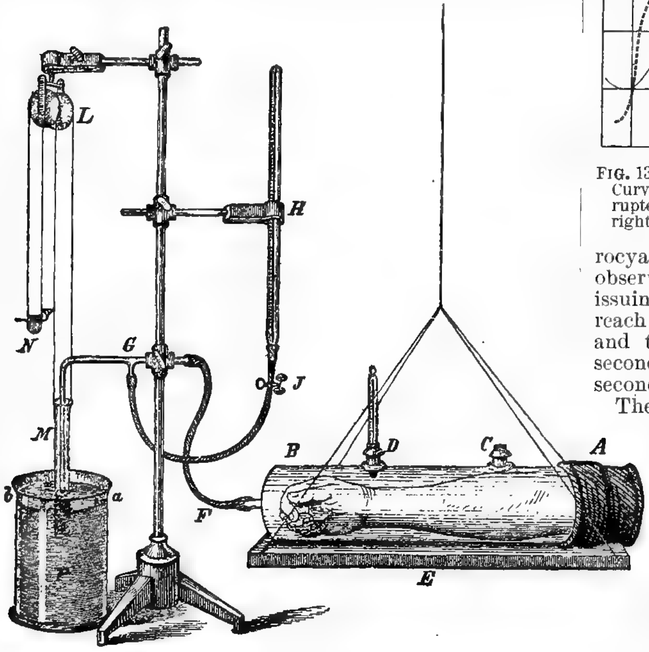

FIG. 1339.—Plethysmograph. (According to Mosso.)

γ. Posture.—Changes in the position of the limbs and body also affect the pressure in the veins by altering the tension of their walls (Braune). Thus in walking, the femoral vein where it passes under Poupart's ligament collapses when the leg is rotated backward and outward, but fills again when the leg returns to its first position, the whole movement making a kind of suction and pressure apparatus.

δ. Gravity.—In the upright position of the body, the difference of hydrostatic pressure in the vessels of the head and feet amounts to 1.75 metres of water or 129 mm. mercury. This naturally opposes an upward current and assists a downward one, so that the effect on the arteries and veins is equal but opposite in direction. The result is that it modifies the distribution rather than the rate of flow of the blood, as may be seen on comparing the pale, anæmic condition of the hand when the arm is raised with its full, red appearance when the arm hangs down.

When from any combination of circumstances the blood returns to the right side of the heart in excessive and dangerous amounts the liver is supposed to play the rôle of a shunt by taking up a considerable quantity of blood, much in the same way as it does after profuse intravenous injections (see above).

5. The Time of a Complete Circulation. This was first determined by Hering (1829) by injecting potassium ferrocyanide into the central end of the jugular vein and observing the time of its first appearance in the blood issuing from the peripheral end of the same vessel. To reach the latter point a complete circuit had to be made, and the time thus determined was found to be 31.5 seconds in the horse; 16.7 seconds in the dog; 7.79 seconds in the rabbit.

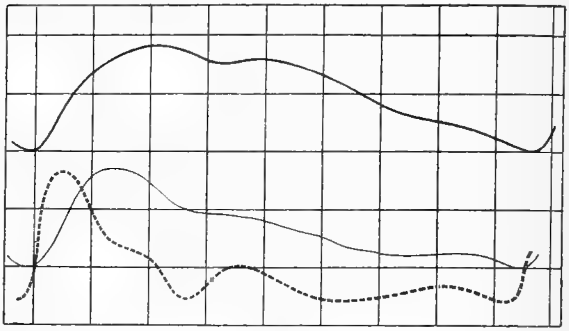

FIG. 1340.—Plethysmographic Curve (Upper Continuous Line), Pulse Curve (Lower Continuous Line), and the Velocity Curve (Interrupted Line) in Man. (According to Fick.) To be read from left to right.

The time is not much affected by the length of the course in the same animal, because the difference between the longest and shortest path would be made up mostly of the larger trunks, where the rate of flow is most rapid. Dividing the time in seconds given above by the length of the cardiac cycle for the corresponding animal, it appears that the circulation time covers from 26 to 28 heart beats. The same rule applied to man would give as the circulation time:

$$27 \times \tfrac{60}{72} = 22.5 \text{ seconds.}$$

These measurements possess only a relative value, because the method does not take into account the error arising from the diffusion of the salt during the time of its transit and from the fact that the first appearance of the salt is really determined by the maximal or axial velocity of the current. The mean time should therefore be taken as at least twice as great as the observed time.

6. The Pulse. The intermittent character of the circulation in the arteries has been referred to in more than one connection. With each systole of the ventricle a temporary increase of pressure, size, and velocity above the mean results from the sudden accession of the extra volume of blood to that already present in this part of the system. The pressure oscillations are readily felt in superficial arteries, and the resulting expansion has long been known technically as the "pulse." It can be graphically recorded, as Vierordt first showed (1855), and Marey soon afterward (1860) devised his well-known sphygmograph in order to obtain an accurate reproduction of the movement in all its phases. When recorded

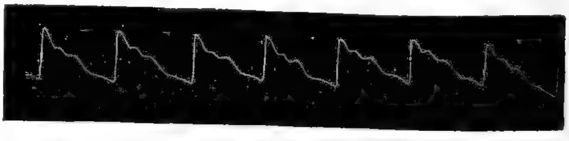

FIG. 1341.—Sphygmogram taken from the Radial Artery with a Marey Sphygmograph. (According to Langendorff.) Read from left to right.

on a travelling surface, the curve or sphygmogram like that represented in Fig. 1341, is obtained.

The rise of the curve is quite sudden, while the downstroke is more gradual and interrupted by one or more secondary waves. The phenomenon of the pulse is entirely explained by the interaction of a number of physical factors, resulting as it does from the sudden injection of the contents of the ventricle into the elastic arteries, which are already full and whose outlet is partially blocked by the peripheral resistance. The actual height and form of a given pulse-curve depends much on the adjustment of the instrument; but if a series of curves are taken from different arteries under the same conditions, it is found that their character undergoes definite changes according to the distance of the corresponding arteries from the heart. The carotid curve, for example, rises higher and more suddenly than the radial curve; this in turn is higher and steeper than the tibial pulse curve. In other words, the pulse curve grows lower and flatter toward the capillaries, and under ordinary conditions it disappears entirely by the time they are reached.

The more rapid rise and greater amplitude of the pulse near the heart is the immediate result of the suddenness with which the ventricle is emptied. The additional quantity of blood thus thrown into the arteries starts a wave of positive pressure down the arterial tree, but on account of the resistance ahead it first expands the aorta and its largest branches. The distant arteries, therefore, do not feel the full force of the systole as would be the case in a system of rigid tubes; when the wave reaches them it has been damped by a longer or shorter stretch of elastic arterial wall. The recoil of this wall is less sudden than the contraction of the heart, and so the expansion of the successive segments becomes more gradual.

The loss in amplitude is also readily explained by the elastic character of the vessels. The energy of the wave is gradually spent in spreading over an increasing area of elastic tubes every portion of which for a brief period remains distended a little more than before. Each section of artery thus makes a levy on the extra expansion as it is passed along, and transmits it to the next section diminished by that much. This is, in fact, the only way in which the mean arterial pressure can be produced and maintained. This process, of course, is further accelerated by the rapid increase of elastic surface as the bed widens, not to mention the loss resulting from partial reflections with consequent interferences of the wave at every bifurcation of the vessels.

Under certain circumstances the pulse may pass through the capillaries into the veins beyond. The increased vascularity of organs during periods of heightened functional activity is secured by a wide dilatation of their small arteries. The peripheral resistance, so essential in bringing the elasticity of the arteries into play, is thereby locally diminished and the dilated vessels cease to do their share toward destroying the remnant of the pulse which comes down to them from the larger arteries. The blood flows more readily through the widened channels, and frequently issues from the corresponding veins in a rapid, pulsating stream.

This true venous pulse, appearing under special conditions in the small peripheral veins, must be distinguished from the pulsations which are sometimes observed in the great veins near the heart. The latter are caused by changes of pressure transmitted backward from the heart and thorax, and are often described as constituting a "venous pulse."

The special features of the pulse curve, including the number and character of the secondary elevations, are interesting on account of the suggestions and indications they give concerning the action of the heart, the condition of the vessels, and the state of the blood pressure. For these the reader is referred to the special article on the pulse (see *Sphygmography*).

The rate of transmission of the pulse wave, which must not be confounded with the onward movement of the blood itself, is found by taking simultaneous records of the pulse from arteries unequally distant from the heart. If the distance of the two points from the heart is known, the rate of propagation is easily calculated, and it has been found to vary normally between 5 and 10 m. per second. The rate depends mainly on the degree of rigidity of the arteries, the wave travelling slowly when the mean blood pressure is low and in the soft distensible arteries of children, while its velocity is increased by high arterial pressure and the hardening of the arteries in old age. In any case the pulse wave moves many times faster than the blood itself, being, as we have seen, merely a wave of pressure which is started in the aorta and which travels over the blood exactly as a water wave passes over the surface of a stream independently of the rate and direction of the latter's own current. The ordinary pulse curve does not return to the base line from which it started until the rise due to the next wave begins, indicating that the wave requires the entire time of a cardiac cycle to pass a given point. With a heart beating at the rate of 72 per minute, this would equal $\frac{60}{72}$ second, and taking the velocity of the wave at 6 m. per second, we would have as the length of the wave $6 \times \frac{60}{72} = 5$ m. This is several times greater than the distance of the farthest capillaries from the heart, showing that the beginning of the pulse wave is lost at the periphery some time before the end of it leaves the aorta.

7. The Pulmonary Circulation and its Relation to the Systemic.

a. The maintenance of the circulation as a whole implies that the average output of the two ventricles of the heart is the same. Considering the relatively small capacity of the pulmonary circuit, which normally contains only one-twelfth of the total blood (Hegel and Sprehl), the time spent in this part of the vascular system must be much shorter than that taken for the major circuit. The pressure in the pulmonary arteries has been measured upon various animals by numerous observers with very discordant results; in general it seems to range between one-third and one-fifth of the aortic pressure, being given at 20 to 25 mm. Hg. for the dog.[7] This indicates a low resistance in the pulmonary capillaries, and the great distensibility and slight tone of the pulmonary vessels are perhaps the most striking features of the lesser circulation.

The influence of the respiratory movements on the pulmonary circulation is a complex one and depends on several factors. The expansion of the lungs in a normal inspiration has been shown to dilate the pulmonary vessels. This diminishes the resistance and tends to lower the pressure in the pulmonary artery. At the same time the output of the right ventricle is augmented by the increased aspiratory action of the thorax, which we have seen hastens the return of the blood to the right auricle and so increases its diastolic distention. This factor would tend to raise pulmonary pressure, and actual measurement alone can determine which of the opposing tendencies will have the upper hand. In certain cases, at least, it has been shown that the dilatation more than compensated for the increased output of the heart and the pressure in inspiration fell (Talma). In natural expiration the conditions are reversed and the pressure again rises. The course of events is entirely different during artificial respiration, when the lungs are inflated under positive pressure with the thorax open.

The great range of adaptibility, as regards its capacity, shown by the pulmonary circuit deserves special mention. In dogs about three-fourths of this vascular area was occluded without producing any effect on aortic blood pressure (Lichtheim). Since the systemic venous pressure in this experiment also remained normal, the amount of blood passing through the lungs was evidently not reduced by this extensive narrowing of the path. The pressure in the remaining pulmonary artery was, however, raised by the operation, and it is supposed that this rise of pressure distended the open channels sufficiently to explain the undiminished flow through the lungs. It is doubtful whether this observation, made under abnormal conditions, can be applied generally: at least in rabbits with pleural cavities intact clamping of one pulmonary artery caused a decided drop in the systemic blood pressure. It is merely given to illustrate the possibilities of capacity change in the lung vessels. They can easily be distended so as to retain enough blood to lower the carotid pressure to zero, as shown in some experiments on differential respiration.[8]

The pulmonary circulation is affected not only by the condition of the systemic circuit at its venous end, but also by that of the arterial side. An excessive transfusion or a powerful general constriction may so increase the work of the left ventricle that it fails to empty itself completely at each systole. A stagnation extending from the left ventricle to the left auricle and thence to the pulmonary veins results, and the pressure in the lesser circuit is raised. The threatened danger from this source to the right ventricle with its thin walls is averted by the power of expansion which has been dwelt upon so fully; so that the lungs may be said to play the same rôle in regulating the blood flow to the left ventricle as that ascribed to the liver for the right ventricle (Tigerstedt).

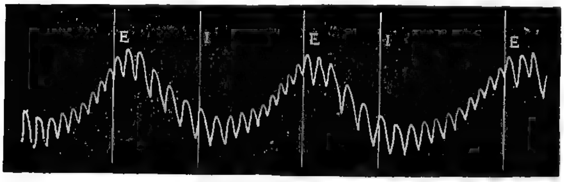

FIG. 1342.—Carotid Blood-Pressure Tracing of Dog. Vagi not divided. I, Inspiration; E, expiration. (Stirling.)

β. Respiratory changes of blood pressure in the systemic arteries. The pulmonary circulation reacts upon the systemic pressure by modifying the inflow to the left auricle. It has been stated that the pulmonary vessels expand during inspiration and constrict during expiration. While the distention is in the act of developing, the blood flow is momentarily retarded and the left heart receives a smaller charge; but once the maximal dilatation has been reached, the resulting diminution of the resistance will augment the flow and the left heart receives a more abundant supply. On the contrary, expiration primarily increases the flow by narrowing the calibre of the dilated vessels and forcing on their contents, and secondarily diminishes it by increasing the resistance. The effect of these changes in the lungs on the pressure in the aorta depends largely on the rate and depth of the respiratory movements. When these are very shallow, no effect whatever is observed in the systemic arteries. When they are both quick and strong, only the primary effects appear, and the aortic pressure falls in inspiration and rises in expiration. The typical result is seen only in ordinary breathing when the rate is slow enough to permit both the primary and the secondary changes to produce their proper effect (see Fig. 1342). In this case the pressure first falls during inspiration to a minimum (primary effect) and then rises again (secondary effect); in the succeeding expiration the rise continues for a short time to the maximum (primary effect) and then the pressure falls again (secondary effect). The main effect of inspiration, therefore, is to raise the pressure and the main effect of expiration to lower it. The curve frequently shows also changes in the rate of the heart which beats slower during expiration and faster in inspiration. These changes are brought about through nervous influences that must be considered later, and it need only be stated in this connection that they are not of sufficient moment to affect the general course of the phenomena here described.

C. *The Mechanics of the Heart.*—The circulation of the blood through the vessels is maintained by the energy of the beating heart. Before considering the causes which generate this beat and which determine its character, force, and frequency, it will be convenient to take up a number of mechanical problems which the heart presents when regarded as a valvular pump in action.

1. External Phenomena of the Beat. *a*. When the living heart is observed directly, either in a mammal, or, better still, in a cold-blooded animal like the frog or terrapin, each beat is seen to begin with a contraction of the great veins in the neighborhood of the heart. The contraction proceeds as a peristaltic wave whose progress can be readily followed in the cold-blooded heart as it spreads first over the auricles and then over the ventricles. In the mammal the wave-like character of the beat is difficult to recognize on account of the great rapidity of the movement. Here the auricles appear to contract suddenly over their whole extent, the auricular appendages being drawn inward and the rest of the wall pressing toward the auriculo-ventricular orifices, without, however, completely obliterating their cavities. As soon as the contraction of the auricles is completed the ventricles immediately follow with theirs. The contraction of each section of the heart is spoken of as its systole, and the succeeding relaxation as the diastole. A complete beat or "cardiac cycle" comprises an auricular and a ventricular systole and a heart pause, during which all parts of the heart are at rest. The systole and diastole of the two auricles are perfectly synchronous in a normal heart as are also those of the two ventricles, the synchronism resulting from the peculiar arrangement of the muscle fibres in their walls.

In the auricles these consist of a superficial set common to both sides and of deeper fibres proper to each. The superficial fibres run transversely, being best developed on the anterior surface, and some of them turn in at the auricular septum. Of the deep fibres, some pass over the auricle in the form of an open loop to be attached at both extremities to the auriculo-ventricular ring; these are called the "looped" fibres. Others, known as "annular" fibres, encircle the auricular appendages and surround the openings of the venæ cavæ and pulmonary veins.

The complex nature of the arrangement of the fibres in the ventricles appears from the fact that a vertical section of their walls taken at almost any point shows the fibres on the outer surface crossing the direction of those on the inner, while between these every intermediate direction may be represented. The left ventricle possesses a much more powerful musculature than the right ventricle, but, as in the case of the auricles, a large number of fibres are common to both; in fact, the outer wall of the right ventricle is so largely made up of fibres

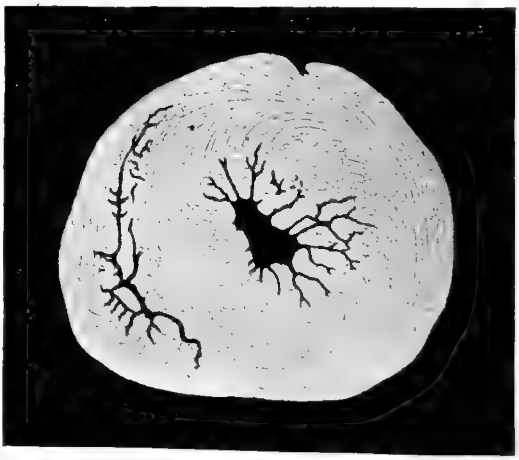

FIG. 1343.—Cross Section of a Completely Contracted Human Heart, at the Level of the Lower and Middle Third. (According to Krehl.)

coming from the left that the former appears in sections of the heart like a cleft or pocket in the wall of the latter (see Fig. 1343).

Schematically the fibres may be described as falling into a number of more or less well-defined groups according to the general direction of their course. The superficial oblique fibres constitute the first of these groups. They take their origin in the fibrous rings at the base of the heart and have a general trend obliquely downward and to the left. They form a thin, superficial stratum on the wall of the right ventricle, but on the left side they increase greatly in number, and on reaching the apex many of them turn in to form the whorl, whence they ascend on the inner surface to terminate in the papillary muscles and chordæ tendineæ or to pass all the way up to the auriculo-ventricular ring.

Between the inner and outer layers of oblique fibres a second group proper to the left ventricle is interposed. The fibres of this class are more or less transverse in direction and may be described as the circular fibres of this chamber, of the thickness of whose wall they make up a considerable share. Taken as a whole, they form a truncated hollow cone through the narrow apical opening of which the fibres of the whorl enter.

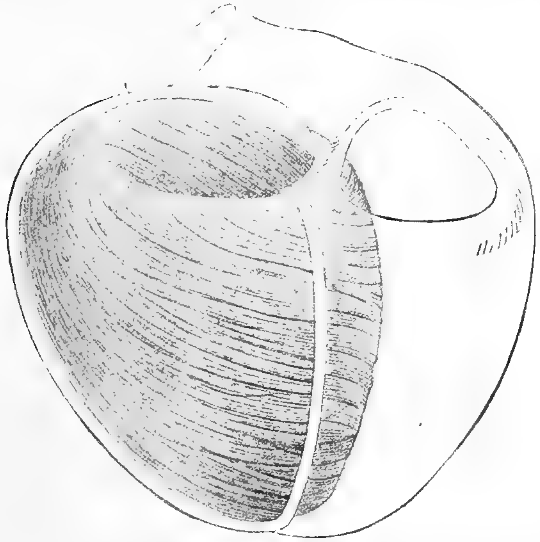

FIG. 1344.—Intermediate Layer of Circular Fibres of the Left Ventricle. The outer and inner fibres have been removed, and the outlines of the entire heart schematically indicated. (According to Krehl.)

The right ventricle also contains fibres of its own, and one set of these can be traced on the inner surface of its outer wall. These take their origin at the upper border of the septum, follow this down for a variable distance, then turning toward the lumen, stretch across to the outer wall. There they ascend in bundles, forming trabeculæ and columnæ carneæ, and end partly as papillary muscles, partly by short tendons in the fibro-tendinous ring at the base.

The portion of the right ventricle known as the conus arteriosus has its own special fibres, which in its outer wall arrange themselves into an inner longitudinal and an outer circular layer, the latter merging insensibly into the superficial oblique fibres of the general surface.

The anatomical basis for the observed synchronism of the two sides of the heart is thus provided for in the large number of fibres which pass across and are common to the chambers of the same name. The progressive character of the contraction, not easily recognized by direct observation, can be demonstrated by means of the accompanying electrical phenomena, which are similar in the case of the heart to those observed in skeletal muscle. An electrical change or current of action accompanies each heart beat; in the frog's heart the variation shown by the capillary electrometer is diphasic.

For the human heart the later work seems to show a triphasic current, first base negative to apex, then apex negative to base, and then again base negative to apex. The accompanying curve has been constructed to represent these electrical variations.

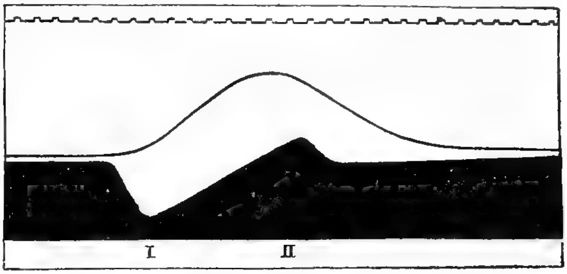

FIG. 1345.—Simultaneous Photogram of a Single Beat (Black Line) and of the Accompanying Electrical Change, indicated by the level of the black area, which shows the varying level of mercury in a capillary electrometer. I, First phase, base negative to apex; II, second phase, apex negative to base. (Waller.)

From them it is inferred that the contraction begins at the base of the heart and advances toward the apex; that for a time (the interval S to T in the curve) the entire ventricle is uniformly contracted; finally, that the contraction ends by disappearing first at the apex. It evidently follows the recurrent path of the superficial oblique fibres, beginning and ending at the auriculo-ventricular groove. Another deduction drawn from the electrical phenomena of the heart is that its contraction is comparable to a simple muscle twitch and is not to be regarded as a summated or tetanic contraction.

β. Changes in the form and position of the heart. In diastole the heart can hardly be said to possess a definite shape of its own, although it is frequently described as a hemi-spheroid with a rounded apex and somewhat flattened anterior and posterior surfaces. On account of its soft, flabby condition its shape changes according to the position of the body under the influence of its own weight. Not so in systole; the heart then becomes hard and rigid and its shape approaches that of a regular cone with a circular base. The changes in the three diameters during this transition must depend on its previous form in diastole. Under normal conditions in which the heart is supported by the lungs as by an elastic cushion, there is probably no extensive flattening in any one plane. In this case entrance into systole would involve a shortening in all directions while the apex became sharper or more pointed.

When the heart is examined in the ordinary way in animals with open thorax, it unquestionably flattens out during diastole, the transverse diameter elongates at the expense of the antero-posterior, and the base takes

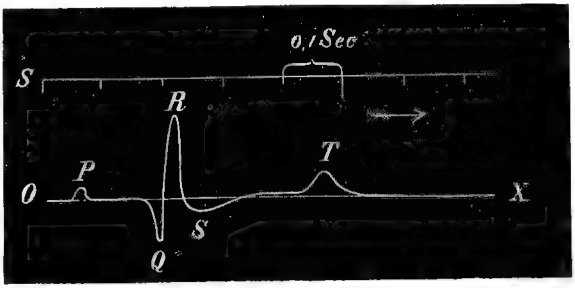

FIG. 1346.—Diagrammatic Curve of the Action Currents of the Human Heart. (Einthoven.) *R*, Beginning of ventricular contraction; *S*, apex negative to base; *T*, third phase, base negative to apex. The small diphasic variations represented by *P* and *Q* are caused by the auricular systole.

the form of an ellipse. In this case, when the elliptical base passes into the circular systolic form, the transverse and the longitudinal axes shorten while the antero-posterior diameter increases in length. On account of the oblique, spiral direction of many of the fibres, the apex is also seen to rotate somewhat to the left and forward, and the longitudinal axis approaches the vertical to the plane of the base. As regards the displacement of the heart as a whole, it is interesting to note that the apex is the stationary point, while the base is drawn toward it in proportion to the decrease in the longitudinal axis. The suspension of the heart from the large arteries should *a priori* make the base the relatively fixed point; its movement toward the apparently free apex is explained by the recoil of the blood as it is driven forcibly through the arterial ostia and by the elongation of the great vessels under the increased systolic pressure.

The effect of the contraction upon the cavities of the ventricles consists in a more or less extensive obliteration of their lumen. Examination of maximally contracted hearts after death shows, however, that this is not complete. On the left side the short, tubular chamber of the relaxed organ is reduced in systole to a mere stellate slit at the level of the papillary muscles, while above their summits this slit widens to an appreciable space of an irregular conical form (see Fig. 1343 above). In the right ventricle also, when the crescentic cavity is reduced to a mere slit by the approximation of the outer wall to the septum, an appreciable opening is left in the upper part below the tricuspid valves, and more especially in the region of the conus arteriosus.

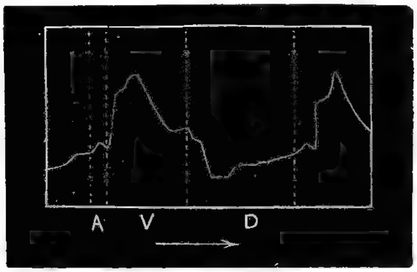

FIG. 1347.—Cardiogram Taken with Marey's Cardiograph. A, Auricular systole; V, ventricular systole; D, diastole. The arrow shows the direction in which the tracing is to be read.

γ. The apex beat. At each systole of the ventricles a shock or impulse may be felt in the fourth or fifth intercostal space about an inch below and a little to the median side of the left nipple. This is where the apex lies against the chest wall uncovered by the lungs, and hence the name "apex beat" or "cardiac impulse" for this familiar phenomenon. In diastole the flaccid wall of the heart yields to the more rigid thorax and the apex is not perceptible to the touch. The sudden hardening of the ventricles as they contract upon their contents enables them to exert pressure against the chest wall so that now the apex can be felt distinctly, its contact with the thorax being made even closer by the forward rotation already referred to. The elevation of the chest thereby produced can be recorded graphically, and the tracings obtained are known as cardiograms.

The cardiogram gives valuable information as to the pressure and volume changes of the heart; its analysis will be attempted in connection with records of the heart's action taken by other methods. Special interest attaches to these curves from the fact that they represent the only direct record of the heart beat that can be obtained from man. (See the section on Cardiography in the article on *Heart.*)

δ. The heart sounds. Another physical sign by which the heart's action can be studied are the sounds which it emits. Normally two sounds, differing in pitch and duration, are audible in each cardiac cycle: the first a comparatively long, dull, booming sound, the second a short, sharp, sudden one. The interval between the first sound and the second is very short, but between the second and the succeeding first sound there is a distinct pause. The first sound is coincident with the systole of the ventricles, more particularly with the closure of the auriculo-ventricular valves, and it is generally regarded as a mixed or combination tone in regard to its origin. It can be heard distinctly in a contracting heart containing neither blood nor air (Ludwig and Dogiel), so that it is partly at least a muscle tone. At the same time, it is probable that in the normally beating heart the sudden closure and tension of the auriculo-ventricular valves throw them and the blood into vibration, and it is possible that similar vibrations arise at the opening of the semilunar valves (Tigerstedt). The sounds resulting from these vibrations, by fusing with the principal element, the muscle sound, have some share in the total effect and thus help in determining its final character.

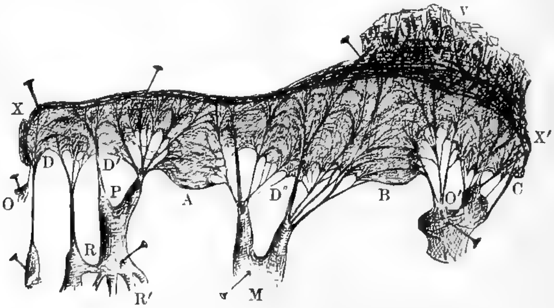

FIG. 1348.—Human Tricuspid Valve—Ventricular Surface Spread Out Flat. A, Inferior; B, anterior; C, septal segment; D D' D", lesser segments; M, anterior papillary muscle; O O', papillary muscles attached directly to ventricular septum: P, papillary muscle attached to columnæ carneæ; R R' v, portion of right ventricular wall, showing bundles of fibres continuous with chordæ tendineæ; XX', line of insertion of segments into auriculo-ventricular ring.

The second sound, which marks the end of systole, is purely valvular in origin, being produced by the closure of the semilunar valves. A sound exactly similar in quality can be obtained from the excised aorta by producing sudden tension of its valves. Considering the mode of production of the heart sounds, it is evident that each side of the heart must have a first and second sound of its own, making a total of four sounds. The fact that only two are ordinarily heard (the two first sounds fusing together and similarly the two second sounds) proves again the perfect synchronism of the ventricular contractions. Pathological alterations affecting either the structure of the valves or of the cardiac muscle may dissociate the elements of the mixed sounds, modifying their usual character and quality and even giving rise to new ones. These abnormal sounds are known as cardiac murmurs, and from a study of their rhythm, their posi-

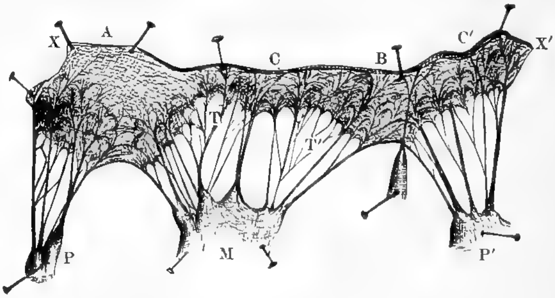

FIG. 1349.—Human Mitral Valve—Ventricular Surface Spread Out Flat. A, Largest cusp close to aortic valve, aortic segment; B, next largest cusp, parietal segment; C C', lesser cusps; M, anterior papillary muscle; P P', posterior papillary muscles; T T', method of branching of chordæ tendineæ; XX', line of insertion of cusps into auriculo-ventricular ring.

tion of maximal intensity, and the direction in which they are propagated information of great diagnostic value is obtained.

2. Internal Events of the Beat. *α.* During diastole, when the whole heart is at rest and its chambers relaxed, the semilunar valves are closed by the high pressure in the arteries. The blood, returning in the veins with a fair velocity and under low pressure, meets with no resistance and enters freely into the auricles, and thence passes onward into the ventricles. The auriculo-ventricular valves at this time are thrown open by the blood stream, but their cusps are more or less approximated by the eddies which return along the walls of the ventricles and carry the blood between them and the valve flaps. Presently the systole begins in the ends of the veins and with a sharp, short stroke passes quickly over the auricles. Without completely emptying themselves, they drive part of their contents into the ventricles where the pressure is lower than in the veins, and thus complete the filling of those chambers. The same reflux currents which previously floated up the cusps continue for an instant after the flow into the ventricles has ceased, and thus the edges of the valves are brought into apposition even before the ventricular systole begins. Their perfect closure is facilitated by the anatomical arrangement of the papillary muscles and chordæ tendineæ.

Each auriculo-ventricular valve may be regarded as a membranous tube attached to the auriculo-ventricular ring by one end along its whole circumference while the other end is deeply incised so as to form a number of separate flaps. These are attached to the inner surface of the ventricle and papillary muscles by tendinous chords arising not only from their free edges but also from their under surfaces. Each flap, moreover, sends its chordæ to more than one papillary muscle, and each of these in turn is attached to more than one valve flap.

As the systole of the ventricles begins and the pressure on their contents increases there is no regurgitation into the auricles. The pressure only more firmly secures the apposition of the thin free edges of the valves, and as they are put under tension the first sound is heard. The chordæ tendineæ prevent the eversion or even the bulging of the valves into the auricles, while the papillary muscles, contracting along with the rest of the heart muscle, serve to take in any slack in the chordæ which might result from the approximation of the base and apex, and so keep them taut. An accessory factor in the closure and support of the valves which deserves mention is found in the reduction in size of the base of the heart during systole with its consequent narrowing of the auriculo-ventricular apertures.

The pressure continues to rise in the ventricles until it exceeds that in the arteries, when the semilunar valves open and the discharge begins. The pressure on the arterial side of these valves being always considerable, their opening must not be thought of as a sudden bursting open with the separate folds thrown against the sides of the artery, but rather as a gentle yielding as the pressure on the ventricular side gains the upper hand. The free edges of the valvular folds are considerably removed from the walls of the sinuses of Valsalva, and this taken in connection with the thick projecting muscular cushions at the arterial apertures, reduces the opening through which the blood is discharged to a somewhat narrow slit. Eddies and whirls are formed in the wider space beyond, constantly tending to bring the valves together, and the moment the outflow from the ventricle ceases they close with such rapidity that no regurgitation occurs and the second sound is produced. The ventricle once more relaxes, the auriculo-ventricular valves open under pressure from the auricular side, and the whole cycle of events is repeated.

β. Intracardiac pressures. A record of the pressure changes in the several heart cavities during the course of a complete cardiac cycle gives the truest account of the force- and suction-pump action of the organ, and valuable hints for the determination of the time relations of the successive events which go to make such a cycle. Many methods have been devised to obtain such a record, and while the curves differ considerably in some respects, certain general conclusions have been obtained from them. In the first place, the upper and lower limits of the pressure reached in the course of an observation extending over a series of beats can be accurately measured by means of a mercury manometer with valves attached so as to convert it into a maximum or minimum manometer (Goltz and Gaule). This method shows that the maximum pressure in the ventricles is distinctly greater than the mean pressure in the corresponding arteries, that of the left ventricle being about 2.5 times as great as that of the right. In an actual experiment De Jaeger found the maximum pressure in the left ventricle of the dog 200 mm. Hg, and in another case Fick found it 160 mm. The pressure in the auricles is considerably lower, the maximum as measured on the right side being usually given at 20 mm. Hg. The minimum pressures in the cavities of the heart may fall below that of the atmosphere. Thus, in the left ventricle of the dog, it varied from −52 to −20 mm. Hg, in the right ventricle it was − 17 mm. Hg, and in the right auricle −12 to −7 mm. Hg. Such values, however, are obtained only when the chest is closed, and the negative pressure of the thorax is partly responsible for these low pressures.

When the heart was exposed and the pericardium opened the lowest pressure in the left ventricle was −7 to −25 mm. Hg, and in the right, −1 to −2 mm. Hg, according to Goltz and Gaule. This observation has been confirmed and denied repeatedly, but the balance of evidence seems to favor the view that the diastolic expansion of the heart walls may in itself produce a certain amount of suction, depending largely on the force and suddenness of the foregoing systole. Various suggestions have been made to account for it.

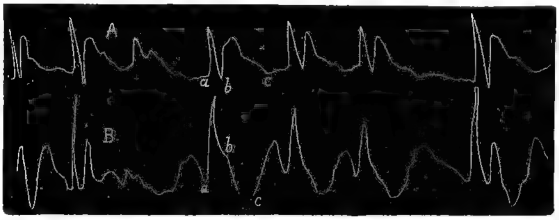

FIG. 1350.—Showing Curves of Pressure (A) and Velocity (B) in the Coronary Artery of the Horse. (Chauveau and Rebatel.)

An elastic expansion of the ventricular walls has been assumed in this connection by some, but the evidence is all opposed to this view. A more efficient cause is probably to be found in the passive expansion which results from the peculiar conditions surrounding the coronary circulation. The filling of the blood-vessels in the walls of the heart should open up its cavities much in the same way that a double-walled bag is distended by filling the space between the two layers. Brücke's theory of the "Selbststeuerung des Herzens" was, in fact, based on this sort of mechanism. It assumed that the semilunar valves were thrown back during systole far enough to prevent the entrance of blood into the coronary arteries, whose distention at that time would oppose the systole; but when, at the onset of diastole, the coronaries are opened and the blood enters under strong pressure from the aorta, the diastolic expansion would be materially assisted. This theory has since been shown to be a curious mixture of truth and error. Martin and Sedgwick[9] demonstrated that the pulse in the coronaries was synchronous with that in other systemic arteries; therefore Brücke was wrong so far as the mechanism by which the systolic dilatation of the coronary vessels is prevented is concerned. The semilunar valves do not shut up the orifices of these arteries. Measurements of the velocity of the blood flow in the coronary arteries by Chauveau and Rebatel have shown, on the other hand, that he was right as to the facts.[10]

Their curves (see Fig. 1350) show that the tension and rate of flow both increase in the coronary artery at the beginning of systole (*a*): *i.e.*, blood streams into it at this time. Then a second rise of pressure is observed during which, however, the velocity curve drops below the abscissa (*b*). This is the moment when the contraction of the ventricle becomes powerful enough to compress the intramural vessels and squeeze out their contents; hence the rise of pressure and the reversed current in the main vessel. Lastly, a new acceleration of the rate, not accompanied by a rise of pressure, appears (*c*); the diastole has begun, the vessels are once more free, and the flow of blood through them is re-established.

Porter[11] has recently added new testimony on this point in the form of observations on the outflow from the coronary veins during different phases of the heart's action. Among other results he found that the volume of blood passing through the coronary vessels is increased by an increase in either the force or the frequency of the heart beat, the increase of volume being accomplished largely through the periodical emptying of the intramural vessels by the systolic squeeze of the fibres around them. Some other points of interest concerning the coronary circulation may be briefly mentioned in this connection. The old controversy as to the terminal character of the arteries of the heart has been answered in the affirmative by the recent work from the Harvard laboratory. It was shown that ligature of the individual branches results in infarction and necrosis of circumscribed areas corresponding to the distribution of those branches. The effect of such a ligature on the action of the heart as a whole seems to depend entirely on the extent of the area involved, arrest of the heart following ligature of the R. circumflexus in 64 per cent. of the cases; of the R. descendens in 28 per cent.; of the R. septi in 0 per cent., and of the A. coronaria dextra in 14 per cent.

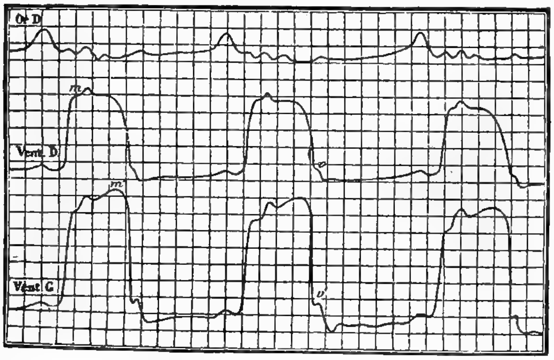

FIG. 1351.—Endocardiac Pressure Curves from the Horse. Or.D, Right auricle; Vent.D, right ventricle; Vent.G, left ventricle. (According to Chauveau and Marey.)

The old theory of a localized coordinating centre upon which the maintenance of the normal beat depends can no longer be defended in the face of these results. Finally the relation between the volume of the coronary circulation and the rhythmic contractility of heart muscle has been investigated by means of an artificial circulation, the applicability of which to the hearts of warm-blooded animals was demonstrated by Martin.[12] The work shows that a surprisingly small flow suffices to maintain a rhythmic beat, the ordinary volume used in the experiments of McGrath and Kennedy[13] upon vigorous cat hearts ranging from 3.5 to 13.5 c.c. per minute. Variations in the amount of blood fed to the heart influenced the force of the beats, while the rate was but little affected.

To return to the subject of intracardiac pressures, the oscillations between the limits given above must recur in the course of every cycle, and the rate at which the changes of pressure are made must be quite swift. It has been estimated that the pressure within the left ventricle rises at the rate of more than 2,000 mm. Hg per second. To obtain an exact record of such a change calls for an instrument with a quick response and low inertia; but the records obtained with the most improved spring manometers of recent years agree so nearly with the older curves of Chauveau and Marey in all essential points that we may assume for the present the correctness of their curves.

The auricular curve shows a quick, sudden rise of pressure which reaches its maximum in about 0.1 second, but returns again immediately so as to form a single rounded peak. This agrees exactly with the sudden brief systole of this end of the heart.

The steep rise of the two lower curves (Fig. 1351) shows that the ventricular systole follows immediately upon that of the auricles and that the pressure goes up with great rapidity. Then there follows a portion of the curves which goes by the name of the "ventricular plateau" because it extends in a direction more or less parallel to the abscissa, sometimes rising, sometimes falling a little, according to the method used. It represents graphically the maintenance in contraction of the ventricles, their systole lasting about 0.4 second. The lever finally sinks back abruptly to the base line and beyond, as shown in the descending limb of the curve.

Intraventricular pressure curves always present secondary elevations distributed over the main curve. They are not constant as to number or form, seemingly changing with the kind of instrument used, and some of them are unquestionably artefacts. Others correspond to definite processes going on inside the heart, as, for example, the small wave which is nearly always seen preceding the large rise due to the ventricular systole. Its position shows that it is synchronous with the systole of the auricle, the effect of which on the pressure in the ventricle is thus recorded.

There is no indication on the record either of the closure of the auriculo-ventricular valves or of the opening of the semilunar valves. An appreciable time must elapse after the beginning of the systole before the pressure mounts high enough to force open the semilunar valves against the arterial pressure; but this being a gradual process, as we have already stated, an effect in the form of a break or notch upon the curve would hardly be expected. By taking simultaneous records of the pressure in the left ventricle and in the aorta it has been shown that the pressure in the latter begins to rise about 0.1 second later than in the ventricle. The point on the curve which corresponds to the time of opening of the valves must be situated, therefore, near the top of the ascending limb and is not marked in any way.

The same indirect method must be relied on to determine, upon the curve, the position corresponding to the closure of the semilunar valves. They will close, of course, the instant the pressure within the ventricle falls below that in the artery, and upon the curve must be represented high up on the descending limb not far from the beginning of the steep descent from the plateau. The curve again shows no record of this event.

γ. The duration of the component elements of a complete cardiac cycle is found most accurately from such records as have just been described. For the human heart, however, it must be estimated from observations on the heart sounds and from cardiographic and sphygmographic curves.

Leaving out of account the slight differences in the figures as given by various observers, the duration of the phases of the human heart, beating at the rate of 70 per minute, may be stated as follows:

Ventricular systole	0.379	second.
Ventricular diastole	.483	"
	.862	"
Auricular systole	0.1	second.
Auricular diastole	.762	"
	.862	"

The heart pause in this case equals 0.383 second. The power of rapid recuperation of the musculature of the heart is impressively shown by these figures. Another point of fundamental importance should be noted in this connection. It will be shown later that the rate of the heart varies within wide limits at different times and under different conditions; but throughout these extensive variations the duration of the ventricular systole remains remarkably uniform. In man, for example, it has been found that the ventricular systole varied only between 0.382 second and 0.190 second when the pulse rate ranged from 32 to 124 per minute. The variations in the rate of the heart are essentially dependent on changes in the duration of the pause, while the systole is but slightly affected. Even the pressure in the arteries has been shown to have no appreciable influence on the duration of the systole, the heart apparently possessing in a high degree the power of adapting its work to the varying demands made upon it without loss of time.

δ. The work done by the heart. In considering the work of the heart, it is treated practically as a force pump which discharges a certain volume of liquid with a known velocity against a given resistance. The auricles from this standpoint become unessential attachments to the apparatus, although physiologically they may be important enough. They not only provide reservoirs for the reception of the blood during the relatively long ventricular systole, thereby avoiding stagnation or damming back in the veins, but, as we shall see later, they constitute a regulating mechanism for the work of the ventricles by determining both the rate of their beat and the extent of their charge.

The suction of the ventricles already explained is here also disregarded. This suction, together with that of the thorax as a whole, is favorable to the circulation in that it assists the return of the blood in the veins. It may be neglected at present as it is quite insignificant in comparison with the other factor concerned, and the blood would return to the heart without its aid under the influence of the impulse given to it by the heart at the arterial end.

The work done by the heart is expended in two ways: (1) The contents of the ventricles must be discharged against a resistance measured by the mean pressure in the aorta and pulmonary arteries. Taking the left side alone for the present, work will be done at each beat equal to $P \times R$, P being the "pulse volume" or the amount discharged in a single systole and R the mean blood pressure in the aorta. (2) Work is done in conferring upon the blood discharged a certain velocity. Now the kinetic energy represented by a mass in motion is expressed by the formula $\frac{1}{2}mv^2$, which if m equals the weight of a body under the influence of gravity, may be written $\frac{pv^2}{2g}$. Applied to the heart, p in this formula represents again the pulse volume, v the velocity in the aorta, and g the accelerating force of gravity, *i.e.*, 9.8 m. (32 feet). The total work of the left ventricle, therefore, equals $PR + \frac{Pv^2}{2g}$ and can be calculated if we know the pulse volume of the heart, the mean aortic pressure, and the rate of flow in the aorta. The two latter have been determined with a fair degree of approximation and may be taken at 150 mm. Hg for the pressure and 500 mm. per second for the velocity. Neither of these figures is very exact, but the error introduced by inaccuracies in them has little effect on the result as compared with that due to our ignorance of the pulse volume. An exact determination of the latter would furnish the key to many problems in the mechanics of the circulation, and frequent attempts have been made to get at it. The estimates given for the human heart vary all the way from 45 to 188 gm.; for the present 100 gm. may be taken as a fair average, although the true result will probably be found somewhat less than this.

Substituting the given values in the formula and making the correction for the specific gravity of mercury (13.6), we obtain as the work of the left ventricle:

$$w = 100 \times 0.150 \times 13.6 + \frac{100 \times 0.500^2}{2 \times 9.8}$$

$$\text{or} \quad w = 204 + 1.28 \text{ gm.-metres of work.}$$

The calculation for the right ventricle is made in the same way, the pulse volume of the two sides of the heart being assumed to be equal and the mean pressure in the pulmonary arteries being taken at $\frac{2}{5}$ that in the aorta. The work of the right ventricle is therefore equal practically to $\frac{2}{5}$ of 205.28, or 82.11 gm.-metres.

Multiplying the work of both sides (287.39 gm.-metres) by the number of beats per minute (70) and by the number of minutes in twenty-four hours (1,440), the work of the heart done in one day is found to equal 28,969 kgm.-metres as a conservative estimate. This represents a considerable percentage of the total energy production in the body, when it is remembered that the mechanical work done by a man in eight hours is estimated at about 125,000 kgm.-metres and that of the muscles of respiration in twenty-four hours amounts only to 11,700 kgm.-metres.

ε. The rate of the heart. It is a matter of some practical importance to the physician to know the normal rate of beat of the heart, and on this account numerous statistics have been compiled with the view of determining the relative influence of the various conditions and circumstances which affect it. Ordinarily the pulse rate presents more or less regular and extensive variations in the course of a day, which are sometimes designated "diurnal." They are hardly the expression of an inherent rhythmicity, since they almost disappear when the subject rests quietly in bed and abstains from food and drink, but rather the result of the complex and ever-changing activities which characterize the successive periods of a complete day.

The most potent of these physiological factors which affect the heart rate in any given individual are temperature and exercise. Experiments on the isolated mammalian heart[14] have shown that the rate increases with rise of temperature up to about 41° C. Beyond this optimum point, a further rise of temperature becomes harmful and quickly the lethal point is reached (45° C.). A change of temperature may arise from internal causes, as in fevers with their characteristically accelerated pulse, or it may come from external sources, such as the ingestion of hot or cold substances. The latter fact accounts in part for the distinct rise in the daily temperature curve after meals, although the quickened pulse at those times may be due partly to the increased chemical and muscular activity of the alimentary tract.

The effect upon the pulse rate of muscular exercise, which is familiar to every one, is both sudden and marked, and it may almost be stated as a law that the increase in the rate is proportional to the duration and intensity of the work done. On this account the pulse is slow during sleep, when the minimum is usually reached, and the increase in rate on sitting up or standing over that of the recumbent position is probably the result of the muscular efforts involved in maintaining these upright positions. The effect of exercise may be quite transient or it may persist for a considerable time, depending on the length of the previous exertion. Thus a walk of a mile or two at an ordinary moderate gait will keep the pulse rate quickened for thirty or even sixty minutes thereafter, and this long-lasting after-effect must be taken into account whenever observations on the normal rate are to be made.

Extensive data in which accidental variations from the preceding causes were guarded against have been tabulated in order to determine the influence of sex, age, and size upon the rate of the heart. The conclusions so far reached may be briefly summarized as follows:

Age.—The average pulse rate is highest the first year after birth, being given at 134 per minute in one series of observations; it sinks steadily up to the twenty-first year when a rate of 72 is reached; it remains at this level to about the sixty-fifth year, after which it begins to go up again slightly, rising perhaps to 79 or 80 per minute at the eightieth year.

Size.—The differences just noted depend in large measure on differences in size, although age in itself, apart from size, has some influence. Taking the average of a great number of cases, there is no doubt that tall individuals have a slower heart than smaller ones of the same age, the difference being as much as 23 beats per minute in the first year, but sinking into insignificance later on in life.

Sex.—Comparing males and females of the same age, the pulse rate is found to be more rapid in the latter at all ages from the second year on. Women on the average are a little smaller than men, so that a correction for size should be introduced. Even when this has been done the general statement remains true, although the differences then are smaller than they ordinarily appear.

The following tables, abridged from those given by Volkmann, furnish the basis of the foregoing generalizations:

TABLE I.

Age.	HEART RATE.			Number of observations.
	Maximum.	Minimum.	Average.	
0– 1	160	101	134	59
5– 6	128	70	98	56
10–11	106	56	87	73
15–16	112	66	83	77
20–21	99	59	71	67
30–35	104	58	70	125
40–45	104	50	72	105
50–55	94	52	72	42
60–65	100	54	73	60
70–75	104	54	75	44
80 +	98	63	79	31

TABLE II.*

Age.	MEAN PULSE RATE.	
	Male.	Female.
2– 7	97	98
8–14	84	94
14–21	76	82
21–28	73	86
28–35	70	78
35–42	68	78
42–49	70	77
49–56	67	76

* The average rates in this table were obtained by Guy from twenty-five observations, in each case taken at midday upon fasting individuals who were at rest in a sitting position.

TABLE III.

Height in millimetres.	MEAN PULSE RATE.	
	Male.	Female.
525	158	144
875	110	107
975	101	106
1,075	97	98
1,175	91	94
1,275	88	95
1,375	87	87
1,475	85	84
1,575	75	77

From a teleological point of view the correlation between the pulse rate and the conditions enumerated above is easily understood. It provides an arrangement for adapting the circulation to the intensity of general metabolism through the rate of the heart. The smaller the size of the body, the greater will be the ratio of the surface to the mass and hence the more rapid the heat dissipation; hence to keep up body temperature heat production must be raised in the same proportion, *i.e.*, greater metabolic activity is required which in turn demands a more rapid circulation and a faster heart. In the same way the chemical activity of the muscles is heightened by exercise and again the circulation is accelerated. The exact mechanism by which the quickened pulse is obtained is difficult to determine, being in most cases of a complex character. The effect is sometimes a direct one on the heart itself, effected through the altered physical and chemical conditions of the blood; at other times it is mainly produced indirectly through the nervous system by way of the extrinsic nerves of the heart; usually it is the combined result of various interacting factors.

III. THE REGULATION AND ADAPTATION OF THE VASCULAR MECHANISM.—A rigid circulatory system working with the regularity of a dead model and supplying each organ with the same steady stream of blood, irrespective of its needs, would by its very regularity work its own destruction. In a living organism there must be a continual adjustment in the blood supply to each part with every change in external or internal conditions. The regulating mechanism, as we actually find it, comprises two parts: one connected with the heart, which being central produces general effects only; the other with the peripheral blood-vessels, through which both local and general effects can be brought about. As usual, the coordination and regulation of the blood vascular system are obtained through the mediation of the nervous system, the relation of which to the heart and blood-vessels must now be described.

A. *The Innervation of the Heart.*—It is customary to speak of the nerve supply of the heart as consisting of an extrinsic and an intrinsic mechanism. The extrinsic nerves include efferent fibres, which are supplied by the vagi and the cardiac rami of the sympathetic chain, and which approach the heart at its venous end, and afferent fibres, which pass from the heart at its arterial end and are characterized by their larger size and the presence of the medullary sheath.

In the mammal the extrinsic nerves terminate in plexuses around the arch of the aorta, and from these the intrinsic nerve supply is derived. Branches proceed to the junction of the great veins with the heart to be distributed to the various parts of the organ. Ganglia are abundant on the superior vena cava and are found also on the pulmonary veins, in the walls of the auricles, in the auriculo-ventricular groove and for an undetermined distance down the ventricular walls. Both nerves and ganglia lie for the most part superficially under the pericardium, and as they are traced along the heart from the point of entrance it may be said in general that the proportion of medullated to non-medullated fibres goes on decreasing, and that the number of ganglion cells likewise diminishes, disappearing entirely at or near the apex.

The ganglia are often classified as sinus ganglia and auriculo-ventricular ganglia. This separation into groups is obscure in mammals, but in the frog's heart comes out distinctly, the sinus ganglion located at the junction of sinus venosus and auricles being known as the ganglion of Remak, the auriculo-ventricular ones as the ganglia of Bidder.

In the frog the vagus and sympathetic fibres reach the heart in a common trunk, one on each side, passing along the superior cavæ to the ganglion of Remak. From this, in addition to scattered fibres, two main cords, the anterior and posterior septal nerves, proceed to the ganglia of Bidder. From the latter smaller twigs penetrate the substance of the ventricle, scattered nerve cells occurring for some little distance along their path; but the lower part of the ventricle, perhaps the lower two-thirds, is said to be quite free from them.

1. The Development of the Normal Beat. In order to appreciate the part played by the nervous apparatus of the heart, it will be necessary to consider the mode of development of its normal beat, of which the automaticity, the rhythmicity, and the regular sequence of the several chambers constitute the most striking features.

a. Automaticity. It has long been known that the heart of a cold-blooded animal will continue to beat for hours and even days after it has been removed from the body. There was every reason to think that the mechanism by which the beat is developed is the same in all the vertebrates, and much of the physiology of the heart as worked out on the frog was applied to the mammal. More recently H. Newall Martin[12] succeeded in keeping alive the isolated heart of the latter also by supplying it with a suitable artificial circulation, and the question of its automaticity was definitively settled. The nerves reaching the heart from without were evidently not essential to the beat, for which all the conditions were contained within the organ itself. The heart is an automatic organ whose activity depends on some internal stimulus, and the question as to the nature of this stimulus and its point of attack immediately arises. Two answers have been given and are still current in physiology under the names of the "neurogenic" and the myogonic theories of the genesis of the heart beat.

The neurogenic theory is based on the following considerations: Muscular tissue in general, and especially the more highly differentiated types of it, depends upon its motor-nerve impulses to set it into action, whereas nerve cells constitute the automatic tissue of the body par excellence. Assuming similarity of function or properties in all nerve cells, those within the heart included, an easy explanation of the automatic beat of this organ would be furnished by the rhythmic motor impulses sent to the cardiac muscle by its intrinsic ganglion cells. Those who adopt this view urge in its support the interesting correlation between the number of ganglion cells distributed to each segment of the heart and the degree of spontaneity and rhythmicity which that part possesses. Thus upon the frog's heart, in which the normal beat begins in the large veins leading to the heart and sweeps over the sinus venosus, auricles, ventricle, and bulbus arteriosus in regular sequence, the following observations can be easily verified.

When the heart in dying ceases to beat the several segments come to rest in turn, beginning at the arterial end. The ventricle fails first, then the auricles fail, and lastly the sinus venosus fails. Further, on testing the irritability of the quiescent heart from time to time by means of gentle mechanical stimulation, its eventual disappearance is found to follow the same order as the failure of the natural beat. Lastly, if by means of a series of transverse sections carried through the heart at different levels the ventricular apex alone, or the entire ventricle, or the ventricle with some auricular tissue, be in turn separated from the venous end of the heart, it will be found that the sinus venosus possesses the greatest potentiality to beat, that the power of generating rhythmic spontaneous beats diminishes in the isolated piece as the plane of section approaches the apex, and that the apex itself will not beat spontaneously at all. The several segments of the frog's heart form, as regards their irritability and spontaneity, a descending series: sinus venosus, auricles, entire ventricle, lower third of ventricle—very similar to the series they form when arranged with reference to the number of contained nerve cells. The inference that the rhythmic beat is the result of the activity of these nerve cells is natural and easy, and though based on observations upon the frog's heart it has been extended to the vertebrates generally.

The myogonic theory of the heart denies the immediate physiological connection between the ganglion cells and the development of the beat, and at present finds in them merely nutritive and distributing centres for the intrinsic nerve fibres, putting them on a level with the cells of the sympathetic and other peripheral ganglia rather than with those of the central nervous system. The origin and nature of the beat are referred entirely to the peculiar properties of cardiac muscle, and much evidence has accumulated in support of this view.

It is known in the first place that hearts or strips of heart muscle, entirely free from nerve cells, may under proper conditions pulsate rhythmically in a normal manner. Not to speak of the invertebrate heart, it is a familiar fact that the heart begins to beat in the fœtus long before any nerve cell appears in its vicinity, while a common laboratory experiment consists in suspending under slight tension a strip of the terrapin's ventricle and recording for hours its rhythmic contractions.

In the second place cardiac muscle does possess peculiar properties not found in other forms of muscular tissue, properties which seem to afford an adequate explanation of the rhythmicity of the heart, while its automaticity and normal sequence are at least as easily explained on the myogonic as on the neurogenic theory.

As to the causation of the beat on the myogonic theory, the suggestion has been made that the internal stimulus consists merely in the spontaneous dissociation of the contractile substance. Heart muscle is admitted to be less highly differentiated histologically than skeletal muscle, and may plausibly be assumed to have preserved in a greater degree the primitive and fundamental attributes of undifferentiated protoplasm. Its spontaneity would be an exhibition of the same property which is inherent in the amœba as well as in the ganglion cell and calls for no special explanation.

Another view has come to the front in the last decade, and the stimulus for the contractions of the heart is found again in the blood, as it was at the beginning of the century. The new idea developed in connection with the work on the nutrition of heart muscle. It was long contended that serum albumin is a necessary constituent of artificial nutritive media for the isolated heart, the proteid being added to the mixture directly or else supplied accidentally by the residue of blood and lymph adhering to the meshes of the heart wall. For this reason, it was maintained, isolated hearts could be kept beating on a physiological saline solution for a comparatively short time only. It was found, however, that a heart which had been completely run down on 0.6 per cent. NaCl solution would beat again for a time if a small amount of Na_2CO_3 was added, and when it had come to rest on this mixture, could be started up a second time by the addition of soluble calcium salts, giving a long series of strong and regular contractions. These remarkable observations were the beginning of a prolonged study of the action of the inorganic salts upon the heart, which is still in progress. One result of this work has been to direct attention to the high degree of tonicity possessed by heart muscle. In normal diastole the heart does not relax completely; it stops in a condition of permanent partial contraction, which constitutes its tone. This is obvious on comparing the normal diastole of a heart with the extreme relaxation of complete vagus inhibition or of death. The tone or tonicity of the heart, measured by the extent of its diastolic relaxation, was found to vary with the reaction of the medium and with the kind and amount of the inorganic salts present. Weak acids diminish, alkalies increase the tone, and a similar antagonism holds good between the potassium and calcium salts. The tone of the heart is, therefore, intimately dependent on the nutritive exchanges going on within its substance, and its diminution or loss may be an important factor in cases of dilatation of the heart. The subject of tonicity of the heart thus becomes a matter of practical importance from the standpoint of clinical medicine. Another result was the discovery of the special relation of the inorganic salts, particularly of calcium and potassium salts, to the causation of the beat[15 16]. Calcium not only diminishes relaxation and increases the tone, but it promotes contraction so that excess of this reagent brings the heart to a standstill in powerful systole. Potassium produces the opposite effect, and a normal rhythmic beat can be maintained only by preserving a proper ratio within comparatively narrow limits of these two classes of salts. From these and similar observations along the same line the conclusion has been reached that the beat of the heart in its normal relations in the body is the result of the interaction of the inorganic constituents of the blood with the heart muscle, the former providing the adequate stimulus, the latter the irritable agent whose complex living molecule responds to the stimulus with an explosive decomposition and furnishes the energy of the contraction.

β. Rhythmicity. On the assumption made in the foregoing paragraph the stimulus to the heart is constant while the response is intermittent and rhythmic. This kind of relation between a continuous stimulus and an intermittent reaction is not peculiar to the heart, although it is perhaps most conveniently demonstrated upon strips of ventricular muscle. When these are suspended under a certain tension, the mechanical stretching of the fibres, acting as a constant stimulus, causes them to give a series of rhythmical contractions. The reason for this is found in the peculiar alterations in irritability which accompany the beat of the heart. When the contraction of the whole heart or of an isolated strip of heart muscle is recorded by means of a lever, the curve of contraction, after a relatively long latent period, rises slowly to a maximum and as slowly declines again. The entire duration of it varies in different animals; but the curve shows an unmistakable resemblance to the simple contraction curve of skeletal muscle. The electrical changes in the heart accompanying its beat corroborate the view that the beat corresponds to a single twitch, and the dictum that "the heart knows no tetanus" has long been current in physiology. Recently Walther[17] showed that under certain abnormal conditions a limited amount of fusion and summation of contractions, and hence incomplete tetanus, could be obtained in the case of the frog's heart; but normally this is never supposed to occur. The reason why heart muscle never gives tetanic contractions but responds rhythmically to rapidly repeated or constant stimuli is found in the so-called "refractory period" (Kronecker, 1874; Marey, 1876), which prevents fusion of contractions, and in the "law of maximal contraction" (Bowditch, 1871) which prevents summation.

When one stimulates a skeletal muscle with a strong stimulus, a large contraction follows; when a weak stimulus is applied, the contraction is small; within limits the contraction is proportional to the stimulus. Not so with the heart. The beat is always the best which the ventricle can accomplish at the time being, be the stimulus weak or strong, provided only it is efficient to provoke a response at all. With the heart it is "all or nothing." Moreover, the effect of a stimulus applied to the ventricle, when it is beating rhythmically either spontaneously or as the result of rhythmic stimulation, will depend upon the exact phase of the cycle of the beat at which it is thrown in. If it is thrown in just as a relaxation is taking place, a beat follows prematurely before the next beat would naturally follow, this premature beat being obviously produced by the stimulus. But if it be thrown in while a contraction is going on, no premature beat follows: the ventricle does not seem to feel the stimulus at all. This period, during which the ventricle is insensible to stimuli, is called the "refractory" period. From this it results that, when a succession of stimuli repeated at a certain rate are sent into the ventricle, the number of beats does not correspond to the number of stimuli; some of the stimuli falling into refractory periods are ineffective and produce no beat. Hence the impossibility of producing tetanus of the heart by means of rapidly repeated stimuli, the usual effect of which is to throw the heart into the condition of incoordinated contraction known as fibrillary contraction or heart delirium. When a premature extra-contraction is induced by sending an intercurrent stimulus in during the diastole, this contraction will be larger the later the stimulus is thrown in. After this contraction a longer pause than usual follows, the *compensatory* pause, and the succeeding systole will be correspondingly increased, so that both the rate of beat and the work done are regulated by this compensation.

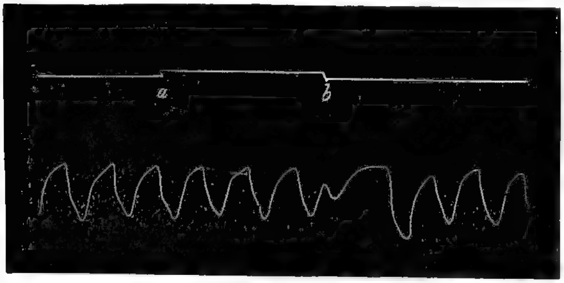

FIG. 1352. Direct Stimulation of the Isolated Heart of the Cat. (According to Langendorff.) To be read from left to right; systole is represented by the down-stroke. The stimulus thrown in at *a*, beginning of systole, remains ineffective; stimulation at *b*, middle of diastole, causes an extra contraction. The compensatory pause and the increased contraction following it are also shown.

γ. Sequence of the beat. The beat of the heart normally begins at the venous end and sweeps over the organ to finish at the arterial end. The myogonic theory, therefore, must provide a plausible explanation for the origin of the beat at one point and its propagation in one direction over the heart. In cold-blooded animals as well as in mammals (Kent) there is direct muscular continuity between the several segments of the heart, so that anatomically there is no difficulty in assuming the propagation of the contraction wave from muscle fibre to muscle fibre through the entire length of the organ. Measurements of the rate at which the contraction wave advances have been made; in the frog's heart at 8° to 12° C. it is 30 to 90 mm. per second, in the excised mammalian heart about 8 m. per second (Waller and Reid). This would indicate that the above assumption is true, these rates being very much slower than the rate of conduction in nerves. It remains only to inquire why the beat begins at the venous end. It was shown above, in connection with the neurogenic theory, that the potentiality of beating was greater in the sinus of the frog's heart than in the other parts. The isolated ventricle, when it beats at all, does so with a slower rhythm than the sinus. Similarly it can be shown on the terrapin's heart that interference with the muscular substance of the auricle, when carried to a certain extent, prevents the beat of the auricle from passing over to the ventricle so that the sequence is broken after the auricle beat. If, for instance, the auricle be cut through until only a narrow bridge of muscle be left connecting the sinus end with the ventricular end of the heart, or if this part of the auricle be compressed with a clamp, a point may be reached in which every second or every third beat only of the sinus is followed by a beat of the ventricle. Then if the bridge be still further narrowed or the clamp tightened, the ventricle stops altogether, or it may after a while set up an independent rhythm of its own, slower than that of the sinus. Experiments upon isolated strips taken from the sinus, auricle, and ventricle respectively show that the concentration of salts in the blood is adjusted to the irritability of the venous end. Sinus strips begin to beat at once in solutions of that degree of concentration; ventricular strips remain quiescent until the concentration is altered to suit their peculiar state of irritability. The normal sequence, therefore, is merely the result of the fact that the normal stimulus of the heart is attuned, so to speak, to the physiological properties of the venous end; the beat once inaugurated travels along from fibre to fibre until the cycle is completed. And so the auricle, as has been stated before, becomes the pacemaker of the entire heart and an important regulator of its work.

2. The Extrinsic Nerves of the Heart. While the heart contains within itself all the conditions necessary to the development of a regular rhythmic beat, its activity is constantly controlled and modified by impulses coming to it through the extrinsic cardiac nerves. It has already been stated that these nerves are derived from two sources, and their anatomical course from the cardiac plexus to their central origins may, for the various mammals, be broadly represented by the diagram (Fig. 1353).

The vagus (inhibitory) fibres, shown by black lines, run in the upper (bulbar) roots of the spinal accessory, by the internal branch of the spinal accessory, past the ganglion trunci vagi, along the trunk of the vagus, and so by branches to the cardiac plexus. The sympathetic augmentor fibres, also shown by black lines, pass from the spinal cord by the anterior roots of the second and third thoracic nerves (possibly also from the first, fourth, and fifth, as indicated by broken black lines), and reach the sympathetic chain in the corresponding white rami communicantes. They pass the stellate ganglion by the annulus of Vieussens to the lower cervical ganglion, from whence, as also from the annulus itself, they pass along the cardiac rami to the plexus.

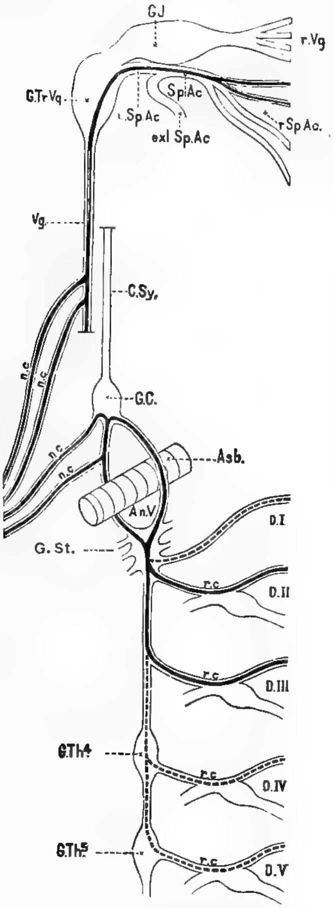

FIG. 1353.—Diagrammatic Representation of the Cardiac Inhibitory and Augmentor Fibres in the Dog. The upper portion of the figure represents the inhibitory, the lower the augmentor fibres.

α. The inhibitory nerves of the heart. The brothers Weber discovered in 1845 that stimulation of the peripheral stump of the divided vagus nerve with the faradic current caused either a slowing or complete cessation of the heart beat, according to the intensity of the stimulus; that the vagus, in other words, contains inhibitory fibres for the heart. Section of both nerves they found to be followed by an acceleration of the pulse, the effect being more pronounced in animals of slow pulse. The inhibitory action of the vagus on the heart is conveniently demonstrated upon a blood-pressure record, in which the altered heart rhythm as well as its influence on the height of arterial pressure is immediately apparent.

The slowing of the beat is, however, not the only effect of vagus stimulation on the heart. The force and extent of the individual beats are also diminished, and the effects upon the rate and force are to a certain extent independent of one another, so that in a given case the rate may remain entirely unchanged while the contractions go on diminishing in extent and force until complete rest results. The contrary effect of a slowing in rate without simultaneous diminution in size is not known to occur. Finally stimulation of the vagus produces a partial or complete loss of tone, thus allowing more complete relaxation and giving rise to the characteristic over-distended and engorged appearance of the completely inhibited heart.

The inhibition from vagus stimulation tells much more on the auricles than on the ventricles, the extent of the auricular contraction being especially affected. The auricles may be brought to a complete standstill while the ventricles continue to beat, the latter then exhibiting that independent rhythm spoken of above. In a somewhat similar manner the stimulation of the vagus, by affecting the rhythm of the auricles more than that of the ventricles, may lead to a lack of coordination between the two, the specially slowed auricles beating at one rate, the ventricles at another. The question as to whether the vagus acts directly on the ventricles, as it does on the auricles, or whether the effect on them is of a secondary nature caused by the changes in the auricles, must for the present be left undecided.

β. Accelerator nerves. Diametrically opposite changes are set up in the heart on stimulating the peripheral end of one of the accelerator nerves. These nerves are characterized by their lesser irritability, a longer latent period of stimulation, and a more lasting after-effect when compared with the pneumogastrics. With a suitable stimulus an acceleration of the heart amounting to from five to one hundred per cent. may be obtained according to the initial rate on which the maximum acceleration that can be obtained seems to be independent. As in the case of the inhibitory fibres, the effect is of a dual nature, the increase in rate being generally accompanied by an increase in the size and force of both auricular and ventricular contractions. Either effect may moreover appear alone, so that the name "augmentor" has come to be used side by side with that of "accelerator" for these nerves. In fact, the suggestion has been offered that the heart really receives four distinct varieties of nerve fibres through its extrinsic nerves instead of two, corresponding to the various results obtained by artificial stimulation—namely, accelerating, retarding, augmenting, and depressing fibres.

It is interesting to note the effect of simultaneous stimulation of both inhibitory and accelerator nerves. It was long believed that even feeble stimulation of the vagi was able to overcome comparatively strong stimulation of the accelerators, so that when both nerves were stimulated together the inhibitory effect predominated so long as the stimulus lasted. Upon the cessation of the latter, however, the characteristic accelerator after-effect showed itself in a secondary quickening of the heart, indicating that the effect of the stimulus on the accelerator nerves was only temporarily superseded.

The recent work on this subject has shown that these two sets of nerves are true antagonists, and that the effect of simultaneous stimulation is determined entirely by the relative strength of the stimuli applied to them. Hunt[18] concludes that in all cases the result is approximately the algebraic sum of the results of stimulating them separately.

The mechanism through which these nerves produce their characteristic effects upon the heart and the nature of the ultimate changes underlying the inhibition and acceleration are also points of fundamental theoretical importance.

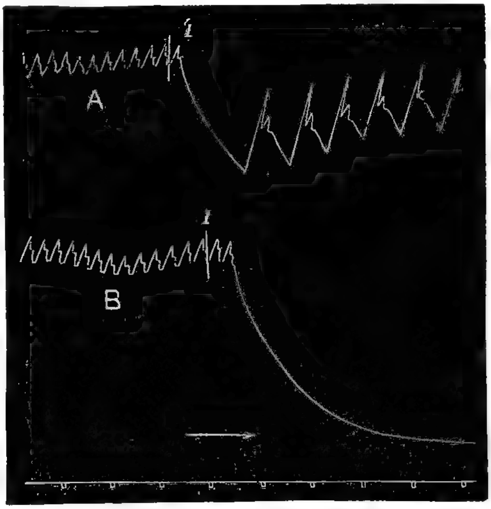

FIG. 1354.—Blood-Pressure Tracing (Rabbit). Vagus stimulated at I. Stimulus stronger in B than in A (Hürthle's spring manometer).

As to the first part, it has been supposed that some of the intrinsic ganglia of the heart constitute peripheral nervous mechanisms which mediate between the extrinsic nerves and the heart muscle. Reasons have already been given for denying to these ganglia any share in the maintenance of the normal beat, and hence the suggestion that they may act as local inhibitory and local augmentor centres. The evidence adduced in support of this view is based on the action of certain heart drugs like nicotine, atropine, and muscarine, and on the interesting classical experiment known as the "ligatures of Stannius." Since neither of these series of experiments is thoroughly understood and both admit of various equally plausible explanations, they have furnished no crucial test or definitive solution of the problem. In fact, it may be said that the alternative view is gaining in favor, according to which the cells on the course of the fibres in the heart are rather stations where the fibres lose their medulla and where possibly other anatomical changes and rearrangements occur, than important intermediate mechanisms which essentially modify the physiological impulses falling into them and which shape the visible results that follow these impulses.

In this case the effect of both inhibitory and accelerator fibres would be upon the muscular tissue direct, and this leads to the second part of the question as to the ultimate nature of these effects. On this point our information is a little more definite, although far from satisfactory. The most plausible theory as to the action of the inhibitory nerves is the trophic theory of Gaskell. While the augmentor nerves are compared to ordinary motor nerves which increase katabolic and destructive changes, the vagus is supposed to have a contrary influence on the chemical changes going on in the heart so as to give them a trophic or anabolic or constructive turn, and thus to lessen for the time being the destructive changes underlying the muscular contraction. According to Gaskell the natural consequence of inhibition should be a stage of increased efficiency and working power when the inhibition has passed away, and the natural consequence of augmentation should be temporary exhaustion. Experiment shows that this is exactly what occurs. The activity of a weak heart has frequently been heightened by vagus stimulation, while a fairly vigorous heart, especially a bloodless one, may by repeated stimulation of the accelerator fibres be reduced to a very feeble condition. In support of the view that the changes set up in the heart by vagus stimulation are of a constructive anabolic kind must be mentioned the positive variation of the demarcation current which accompanies such stimulation. If the ordinary conception that the negative variation accompanying functional activity in various tissues is an indication of increased katabolism be accepted, it is fair to infer from a positive variation that changes of an opposite character are going on.

But the clearest proof of the trophic nutritive influence of the vagus on the heart is obtained from the study of the pathological changes appearing in that organ as a result of unilateral vagotomy in animals. All other organs remain normal while the heart alone presents an area of atrophic degeneration (not fatty degeneration), varying in position according to which nerve was cut (Fantino).

As to the normal mode of functioning of these two sets of antagonistic nerves, it is to be noted in the first place that both are in a state of tonic activity; section of both vagi causes a marked acceleration while subsequent destruction of the accelerators distinctly slows the rate again. These facts point to centres of origin which are in a state of constant activity either automatically or reflexly, and a change in the rate of the heart in either direction may evidently be brought about in two ways, by increasing or diminishing the activity of either of these centres. Nature seems to provide here an excess of regulating mechanism with unwonted and superfluous extravagance, but the general occurrence of this double mechanism throughout the series of vertebrated animals, and even among certain invertebrates,[19] indicates that some useful end must be gained by this arrangement; possibly the great mobility and power of adaptation so necessary in this central organ may be one of the advantages derived thereby.

It is by no means a unique arrangement in the living organization as we find it paralleled by the double mechanism of the iris and by the familiar structure of joints with antagonistic muscles.

The inhibitory and accelerator nerves can be stimulated along their course to the heart only under exceptional circumstances in the intact body. A tumor or an aneurism may occasionally press upon the nerve trunks, or it may be possible in some individuals to compress the vagus against the vertebral column, but the impulses which regulate the activity of the heart are normally discharged from the centres which lie in the medulla oblongata. While there is no satisfactory evidence to indicate the existence of automatic activity in these centres, various conditions are known to modify their activity, and practically every afferent nerve of the body comes into reflex relation with them.

The medullary centres of the cardiac nerves are well known to be influenced by the higher brain centres. Various psychical states, such as pleasure, pain, hope, and fear, may quicken or slow the heart, and occasionally individuals are able by a voluntary effort markedly to accelerate the pulse.

The state of the blood pressure also modifies the activity of these centres. An isolated heart does not react by a change of rate to variations of either arterial or venous pressures within physiological limits[20 21 22]; but in the body with its nerve connections intact it may be almost put in the form of a law, that "the rate of the beat is in inverse ratio to the arterial pressure"; a rise of pressure being accompanied by a diminution and a fall of pressure by an increase of the rate. When the vagi are divided, this relation is no longer observed; hence it is inferred that increased pressure causes a slowing of the beat, when the vagi are intact, because the inhibitory centre is stimulated by the high pressure, either directly by the pressure obtaining in the blood-vessels of the medulla, or in some indirect manner, and the heart in consequence is more or less inhibited. Nothing definite is known as to the conduct of the accelerator centre over against these variations of blood pressure.

The afferent impulses, which reflexly modify the activity of the medullary centre, arise everywhere in the body, including the heart itself, and only a few special cases need be referred to here.

The heart is supplied with centripetal nerves which, while they are not known to mediate conscious sensations, may evoke muscular, vascular, and cardiac reflexes.

Wooldridge described fibres on the anterior and posterior surfaces of the ventricle, stimulation of whose central end gave either reflex acceleration or inhibition.

The depressor nerve of Cyon, which will be referred to in more detail later, also takes its origin in the heart and reflexly inhibits it when the central end is stimulated, the vagi being intact. Reflex inhibition results also from the stimulation of the following nerves: the central end of either vagus, the other being intact; the superior laryngeal nerve; the splanchnic, and the trigeminal.

Reflex acceleration is obtained by forcible inflation of the lungs, and in man whenever intrapulmonary pressure is increased, as in loud talking, singing, etc.

Sensory nerves proper and the nerves of special sense give either inhibition or acceleration, the result apparently depending, in part at least, on the intensity of the stimulus, feeble stimulation giving acceleration, strong stimulation inhibition. It is rarely possible to interpret the result in a given case and to state through the mediation of which centre it is obtained, or whether both centres cooperate, since, as we have seen, either centre may be utilized to obtain both slowing and quickening of the heart. The older physiologists attributed the main share of the reflex regulation to the cardio-inhibitory centre, assigning to the augmentor mechanism a subordinate and auxiliary rôle. At present there is a distinct tendency to magnify the importance of the accelerator mechanism and to place the two halves of the heart-regulating apparatus on equal footing.

B. *Vaso-Motor Nerves.*—From what has been said about the influence of gravity and the respiratory movements on the blood flow in the veins, it may be inferred that these mechanical factors influence the distribution of the blood in the body, more especially that in the veins. Aside from such changes, however, the vascularity of the various organs undergoes incessant fluctuations, which are evidently correlated in part with changes in their functional activity and in part related to the heat regulation of the body. These changes in blood supply are not the passive effects of mechanical factors like those just mentioned, but are brought about by local changes in the walls of the vessels themselves, especially those of the small arteries, by which their calibre is increased or diminished; and these changes throughout the body are so coordinated that in general it may be said that the blood flow to each organ is constantly adapted to the existing state of its physiological activity.

By holding the ear of a rabbit up before the light or watching the web of a frog's foot under the microscope, such changes in the calibre of the arteries may be readily seen. It will be noticed that these vessels frequently expand and contract without any apparent cause, rarely remaining at rest for any great length of time. The size of the vessels thus oscillates about a mean state of moderate contraction, which is habitual though variable and which is spoken of as their tone or tonicity. The arteries owe this tone to the peculiar properties of the non-striated involuntary muscle tissue which enters so largely into the structure of their walls, forming as it does practically the whole thickness of the middle coat in the smaller arteries, where the changes in question are most marked. Histological examination shows, moreover, that these muscle fibres are richly supplied with nerves by which their activity is regulated and controlled, and to which therefore the name of vaso-motor nerves has been given.

The study of the vaso-motor nerves becomes of paramount importance in view of the intimate relations they bear to the activity of every organ and tissue of the body. The fact that the apparently spontaneous irregularly rhythmic changes in calibre of the arteries are under the control of special vaso-motor nerves was discovered by Cl. Bernard in 1851 when he divided the cervical sympathetic nerve in the rabbit. He observed as the result of this operation that the vessels of the ear on the same side visibly expanded, small arteries and veins standing out distinctly which before could not be recognized. The temperature of the ear rose, and from a divided vein blood of a bright hue flowed in a rapid stream. The spontaneous changes of calibre had disappeared. On stimulating the head end of the divided nerve, the arteries again contracted, the venous blood streamed out slowly with the usual dark color, and the temperature of the ear once more fell. Nerves which thus bring about contraction of the vessels when stimulated are called vaso-constrictor nerves, and the experiment cited above shows that the vaso-constrictors distributed to the rabbit's ear are in tonic activity so long as their normal connection with the central nervous system is left intact.

Since the time of Bernard's classical experiment the distribution of nerves of similar function to practically every vascular area of the body has been demonstrated and their anatomical course traced out. In general their path is much the same for all the mammalia, and may be briefly described as follows. Leaving the spinal cord in the anterior roots of the nerves belonging to the middle region, say from the second thoracic to the fourth lumbar nerve, they pass by the visceral branches of the mixed trunk to the corresponding thoracic and abdominal sympathetic ganglia. Those destined for the head and neck come out chiefly in the second and third thoracic nerves, then turn upward through the annulus of Vieussens to the lower cervical ganglion, and thence up the cervical sympathetic nerve to their final distribution. Similarly those for the abdominal viscera pass to the splanchnic and to smaller nerves joining the inferior mesenteric ganglion. The fibres which are intended for the extremities and trunk, after a longer or shorter course along the sympathetic chain, return in the gray rami communicantes to the spinal nerves, and so reach the brachial plexus, the sciatic plexus, or other spinal nerve, as the case may be, to pass out to their appropriate area of distribution.

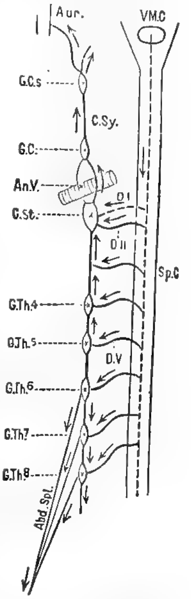

FIG. 1355.—Diagram Illustrating the Paths of Vaso-Constrictor Fibres along the Cervical Sympathetic and (Part of) the Abdominal Splanchnic. Aur., Artery of ear; G.C.s., superior cervical ganglion; Abd.Spl., upper roots of and part of the abdominal splanchnic nerve; V.M.C., vasomotor centre in spinal bulb; C.Sy., cervical sympathetic; G. C., lower cervical ganglion; An.V., annulus of Vieussens; G.St., stellate ganglion; G.Th.^{4}, G.Th.^{5}, G.Th.^{6}, G.Th.^{7}, G.Th.^{8}, thoracic ganglia; D.I, D.II, D.V, thoracic spinal nerves. The paths of the constrictor fibres are shown by the arrows. The dotted line along the middle of the spinal cord, Sp.C., is to indicate the passage of constrictor impulses down the cord from the vasomotor centre in the spinal bulb.

The vaso-constrictor nerve fibres are of the fine medullated variety when they leave the spinal cord, but it has been shown by the nicotine test of Langley that they early lose their medullary sheaths in some one or other of the sympathetic ganglia through which they pass and are continued as non-medullated fibres. Thus the vaso-constrictor fibres of the cervical sympathetic lose theirs in the superior cervical ganglion. The fibres of the abdominal splanchnics are connected with cells of the solar plexus, while others still undergo this change while yet in the main sympathetic chain. Two apparent exceptions to the above general statement are found in the vaso-constrictor fibres which occur in the n. auricularis cervicalis and in the vagus. The former have been traced through the second and third nerves of the cervical plexus and are distributed to the tip and sides of the ear. The vagi, according to various authors, contain vaso-constrictors going to the heart, stomach, intestines, kidneys, spleen, and lungs. The majority of authors agree that the lungs receive their chief supply in the usual way from fibres coming out in the third to fifth thoracic spinal nerves, and it is possible that the apparent exceptions noted may in reality be derived from the sympathetic system.

Another type of vaso-motor nerve is represented in the fibres supplied by the lingual nerve to the submaxillary gland and adjacent structures.

When these fibres are divided no effect is observed; but on stimulating their peripheral ends the vessels of the gland are seen to dilate and swell, and the blood gushes from the efferent veins with a distinct pulse and a bright arterial color. This class of fibres, designated "vaso-dilator" nerves, is not in tonic activity like the vaso-constrictors and their influence can be exerted in one direction only, viz., to dilate the blood-vessels. They seem to be used on special occasions only, while the vaso-constrictor nerves, which owing to their tonic activity can be worked both in a positive constrictor and in a negative dilator direction, appear to find a more general application in the body. At the same time the vaso-dilators have also been shown to be widely distributed and possibly occur wherever the vaso-constrictors are found. The demonstration of vaso-dilator fibres when they occur alone as in the lingual nerve or in the nervi erigentes is not difficult, but when they are combined in the same nerve trunk with vaso-constrictor fibres, as is usually the case, special devices must be used to show their presence. Simultaneous stimulation of both kinds of fibres generally produces vaso-constriction, although marked dilatation may appear as the after-effect.

The vaso-dilators differ from the constrictors physiologically in several ways. When stimulated, the latent period seems somewhat longer, the effect reaches a maximum more slowly and it persists much longer. Their irritability is also of a different kind, disappearing more slowly after section of the nerve or on cooling and making them more sensitive to weak, slowly repeated stimuli. These differences furnished the means of tracing these nerves even in the mixed trunks and of determining their anatomical paths. Some of them appear to run much the same course as the vaso-constrictors. Such are the vaso-dilator fibres running in spinal nerves like the sciatic and brachial, those which seem to be present in the splanchnics, and certain fibres of the cervical sympathetic which act as dilators to parts of the mouth and face. All of these issue from the cord in the anterior roots of the lower cervical, thoracic, and upper lumbar spinal nerves and pass in their course outward through the sympathetic system in essentially the same way as the constrictor fibres.

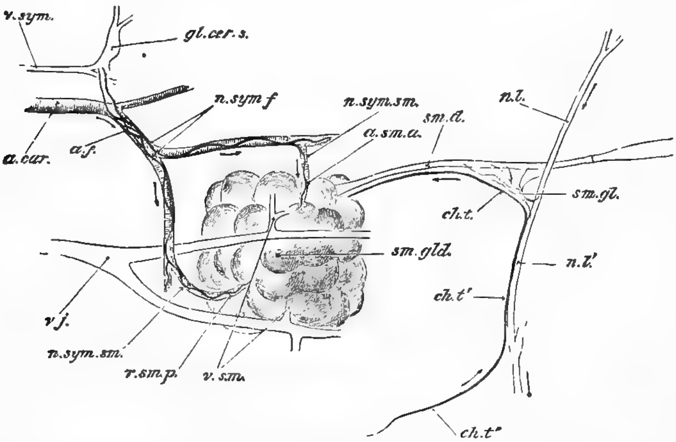

FIG. 1356.—Diagrammatic Representation of the Submaxillary Gland of the Dog with Its Nerve and Blood-Vessels. *sm.gld.*, The submaxillary gland, into the duct (*sm.d.*) of which a cannula has been tied. The sublingual gland and duct are not shown. *n.l.*, *n.l'*, the lingual branch of the fifth nerve, the part *n.l.* is going to the tongue; *ch.t.*, *ch.t'*, *ch.t"*, the chorda tympani. The part *ch.t"* is proceeding from the facial nerve; at *ch.t'* it becomes conjoined with the lingual *n.l'* and afterward diverging passes as *ch.t.* to the gland along the duct. The continuation of the nerve in company with the lingual *n.l.* is not shown. *sm.gl.*, the submaxillary ganglion with its several roots; *a.car.*, the carotid artery, two small branches of which, *a.sm.a.* and *r.sm.p.*, pass to the anterior and posterior parts of the gland; *v.s.m.*, the anterior and posterior veins from the gland, falling into *v.j.*, the jugular vein; *v.sym.*, the conjoined vagus and sympathetic trunks; *gl.cer.s.*, the upper cervical ganglion, two branches of which, forming a plexus (*a.f.*) over the facial artery, are distributed (*n.sym.m*) along the two glandular arteries to the anterior and posterior portions of the gland.

The more distinct and notable vaso-dilators, however, do run a different course. These are found in the nerves coming from the cranial and sacral regions of the central nervous system whence no vaso-constrictor fibres are known to issue. Thus the vaso-dilator fibres for the submaxillary may be traced back through the chorda tympani to the facial or seventh cranial nerve (see Fig. 1356). By the same path vaso-dilator fibres are supplied to part of the tongue also. Of the remaining cranial nerves the glosso-pharyngeal contains vaso-dilator fibres for the parotid gland, the trigeminal for the eye and part of the face (although the latter also receives dilator fibres for the lips, etc., from the second to fifth thoracic nerves through the cervical sympathetic), and the vagus for the coronary arteries of the heart. The vaso-dilator fibres which pass into the nervi erigentes leave the sacral region of the cord by the anterior roots of the sacral nerves and reach the penis by way of the hypogastric plexus. In these instances the vaso-dilator fibres, as they leave the central nervous system, are like the vaso-constrictor fibres, fine, medullated nerves; but unlike the majority, at least, of the vaso-constrictors, they retain their medulla for the greater part of their course and lose it only near their termination in the tissue whose blood-vessels they supply. It should be mentioned also as a curious and remarkable anomaly that some of the vaso-dilator fibres leave the spinal cord in a number of the posterior roots. First discovered in the lumbar region (Stricker, Morat), they have been recently shown[23] to occur in the posterior roots of the fourth, fifth, sixth, and seventh lumbar and first sacral nerves for the posterior extremity, and also in the roots of the cervical and brachial plexuses, especially the seventh cervical and first thoracic, for the anterior extremity.

Veno-Motor Nerves.—The statements made thus far concerning vaso-motor nerves apply entirely to the arterial portion of the vascular system. Now the veins are also provided with muscular fibres and contain plexuses of nerve fibres in their walls. It has, moreover, been known for a long time that they contract in response to various stimuli, and that in certain localities, as in the wing of the bat, rhythmical contractions are displayed. It has only recently been shown physiologically that the veins are supplied with vaso-motor nerves, and the instances on record are still too few to justify any general statements. In 1892 Mall demonstrated the vaso-constrictor fibres to the portal vein in the splanchnic nerve, and showed that through their stimulation as much as twenty-seven per cent. of the total blood could be displaced from the splanchnic area and driven forward to the right heart. Since that time, similar fibres have been traced for the veins of the hind limb,[24] and their general course and arrangement found to correspond to that of the arterial vaso-motor fibres to that limb. In this connection it may be interesting to refer to the observations of Bert and Laffont in 1882 and the more recent work of Camus and Gley,[25] according to which the receptaculum chyli and thoracic duct both receive dilator and constrictor fibres through the thoracic sympathetic chain and splanchnic nerves. It seems plausible to conjecture that the distribution of these two kinds of fibres may be general to all parts of the vascular system

As to the mechanism through which the vaso-motor nerves influence the calibre of the vessels, little can be said. The constrictor fibres represent the motor fibres, whose impulses increase the tone or degree of contraction of the involuntary muscle tissue in the coats of the vessels, while the removal of constrictor influences previously exerted is followed by a passive dilatation under the influence of the blood pressure from within. Whether the influence of these fibres is a direct one on the muscle cells themselves, or whether a peripheral ganglionic mechanism is interposed, must be left undecided as in the case of the cardiac nerves.

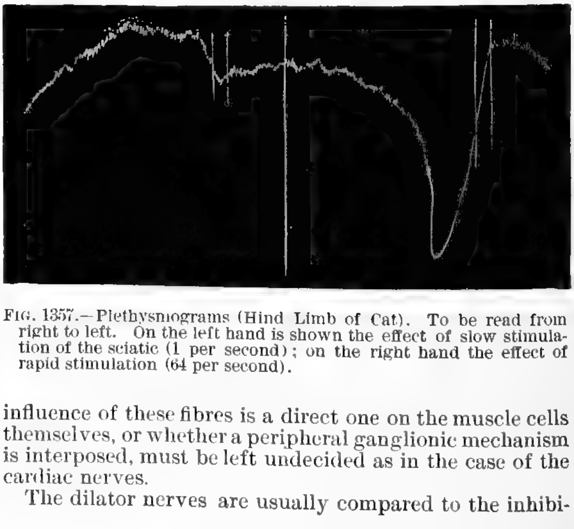

FIG. 1357.—Plethysmograms (Hind Limb of Cat). To be read from right to left. On the left hand is shown the effect of slow stimulation of the sciatic (1 per second); on the right hand the effect of rapid stimulation (64 per second).

The dilator nerves are usually compared to the inhibitory fibres of the heart and the dilatation which they produce is considered a passive one. It has been maintained, however, that they cause an active dilatation of the vessels which is independent of the pressure within, and in support of this view there are on record some interesting observations on the frog's tongue by Frey (1876), which have been recently repeated and perfected by Siawcillo.[26] According to these observers an active expansion of the smallest arteries and capillaries made sufficient suction to start a current in the vessels after the blood had come to absolute rest under a uniform zero pressure An active elongation of the muscle cells and of the capillary endothelium in response to the nerve stimulus alone could account for such an active dilatation, and if proven this would be the first instance of the kind on record.

Vaso-Motor Centres.—The vaso-dilator nerves, whose use is simplified by the absence of habitual tonic influences, occur in connection with organs used chiefly at least as parts of reflex mechanisms, and arise from centres placed in different regions of the central nervous system. Thus the reflex centre for the fibres descending in the chorda tympani lies in the medulla oblongata, while the centre of origin of the fibres in the nervi erigentes is placed in the lower part of the cord; and in general the centre may be said to lie in the central nervous system, not far from the superficial origin of the nerves in which the vaso-dilator fibres run. Nothing more definite can be said, although it is possible that a chief centre for these nerves may exist in the medulla, where the centres for so many vegetative functions are concentrated.

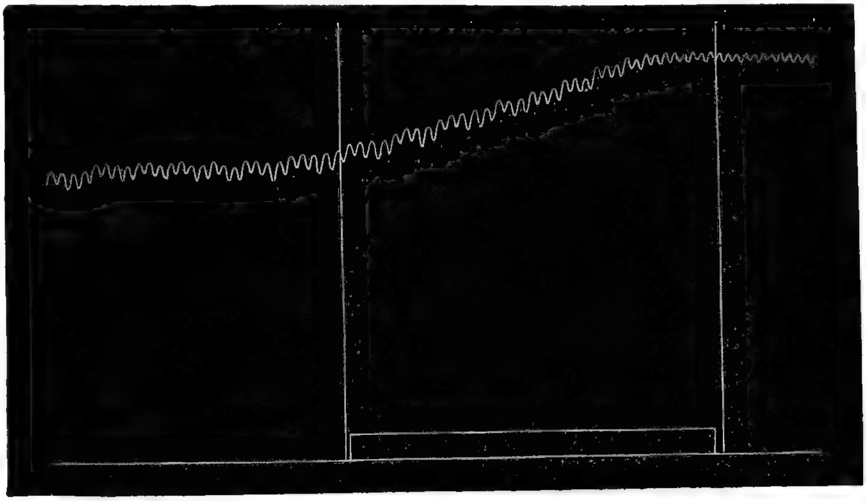
FIG. 1358.—Blood-Pressure Record during Electrical Stimulation of the Depressor Nerve. To be read from right to left. The time of stimulation is indicated by the vertical lines (⊓ = 10 seconds).

The vaso-constrictor nerves are distinctly under the control of a general centre situated in the medulla, occupying a region which extends from a point 4 to 5 mm. above the point of the calamus scriptorius to within 1 to 2 mm. of the corpora quadrigemina. This centre is in continued tonic activity, so that section of the cord below the medulla results in a general loss of tone throughout the vascular system and a great fall of blood pressure. The existence of one presiding centre confers upon the constrictor mechanism the power of producing general effects, and its utility is further increased by reason of its tonic activity, since the same fibres may by an increase in the impulses passing along them be the means of constriction and by the removal or diminution of the tonic influence be the means of dilatation. When an animal whose cord has been divided in the thoracic region is kept in good condition, the arteries of the hind limbs and hinder part of the body which became dilated at the time of the section after a while re-establish a normal or nearly normal tone. This and the fact that they undergo reflex changes of calibre indicate that there are other centres for the vaso-constrictor nerves scattered along the spinal cord. These centres seem to be less irritable than the medullary centre under whose control they normally stand, but their great power of endurance would indicate that they may play an important rôle in maintaining a normal vascular tone. Finally, experiment has shown that the vessels may slowly recover their tone after extirpation of a very large part of the spinal cord. They are at first completely paralyzed and maximally distended; gradually, however, their tone returns and they begin to react to local applications of heat or cold much as they do under normal conditions. It follows that the vessel walls themselves possess the power of exhibiting independent tonic contractility, or else this recovery indicates the existence of vaso-motor centres of a third order in the peripheral ganglia distributed along the course of the nerve trunks. Such a tone of peripheral origin would explain the additional dilatation observed on stimulating vaso-dilator nerves to parts whose vaso-constrictor nerves had previously been divided. From what has been said it follows that the simplest efferent path along which vaso-motor impulses can pass may be considered as built up of two neurones, one with its cell body in the central nervous system and the other in a sympathetic ganglion. Since, however, the spinal vaso-motor centres are under the control of the chief centre in the medulla, the axis-cylinder processes of the cells of the bulbar centre must come into relation with the spinal vaso-motor cells, and so the complete efferent path comes to include three nerve units.

Vaso-Motor Reflexes.—The activity of the centres in the medulla and cord from which the vaso-constrictor and vaso-dilator fibres take their origin is determined in large measure by the impulses falling into them along various afferent nerve channels giving rise to reflex vaso-motion.

The possible afferent paths include practically every centripetal nerve in the body, those distributed to the vessel walls not excepted; while the response may vary from a slight local effect in the region whence the afferent impulse started to a change involving an extensive vascular area sufficient to produce variations in the general blood pressure.

The local reflexes, such as the congestion of the skin on the application of warmth, are commonly dilatations, although constrictions also occasionally result. Of the general reflexes those occurring in the great splanchnic area are perhaps the most frequent, sensory stimulation causing constriction there with special ease. Stimulation of sensory nerves may, however, cause reflex dilatation in the splanchnic region, while in the vessels of the skeletal muscles this is the rule. In them the reaction affects first the muscles which stand in a more or less intimate functional relation with the stimulated nerve, but it may become general and so become an efficient means of bringing on a general fall of blood pressure. It is apparent that the effect on the blood pressure of stimulating a sensory nerve will depend on the relative extent of the antagonistic changes, both of which are usually present, and the question as to the conditions which determine the preponderance of vaso-dilatation in one case and of vaso-constriction in another is one of unusual interest.

We know at present but one nerve, the so-called depressor nerve of Cyon, which with all degrees of stimulation regularly brings on a fall of blood pressure. This is the sensory nerve of the heart which has already been referred to as causing reflex inhibition of the heart. The effect on blood pressure is not dependent on this heart action, as it still occurs after section of both vagi, but is due to an extensive vaso-dilatation in which the splanchnic area has a prominent share, although the vessels of other parts of the body also participate. The dilatation appears to be due to an inhibition or depression of the tonic activity of the vaso-constrictor centre, since the effect is diminished or abolished by agencies which reduce or destroy the irritability of this centre, and hence the name of "depressor" for this nerve. Since sensory nerves in general produce both kinds of effects, "pressor" and "depressor," the interesting discussion has arisen as to whether they contain two distinct varieties of nerve fibres or whether the different results depend entirely on the condition of the centres and the character of the stimuli used. That both of the latter factors may influence the result can be easily shown. A sensory nerve like the sciatic, whose stimulation regularly produces vaso-constriction and rise of blood pressure in an animal under curare, will frequently give a fall of pressure when chloral or ether is used for the anæsthetic. Again, mechanical stimulation of the sensory nerves in muscles by kneading or massage regularly causes reflex vaso-dilatation, while electrical stimulation of the same nerves gives reflex constriction.

On the other hand there is strong evidence for the view that there are both "pressor" and "depressor" or "reflex vaso-dilator" fibres in the sciatic and similar nerves.[27] The pressor fibres ordinarily have the upper hand, but by subjecting the nerve to the action of cold or stimulating the nerve at a certain stage of regeneration after section, the depressor effect may be obtained. The depressor fibres seem to retain their power of conduction longer than do the pressor fibres when cooled, and when the nerve is cut and sutured they regenerate earlier. There is also a certain amount of evidence to indicate that the fall of pressure from stimulation of the sciatic and similar nerves is of a different nature from that resulting from stimulation of the depressor nerve of the heart. In the former case the dilatation occurs largely in the limbs and is probably due to a reflex stimulation of dilator fibres, so that the name "reflex vaso-dilators" has been suggested for this class of fibres to distinguish them from the "depressor" fibres proper which act by inhibiting the vaso-constrictor centre.

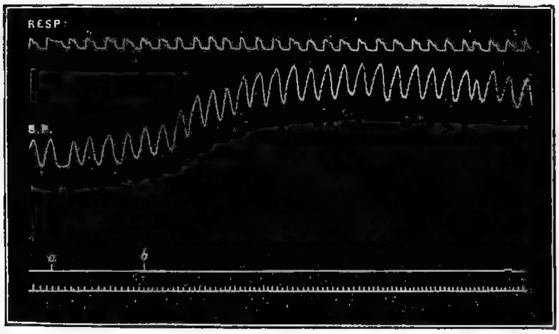

FIG. 1359.—Pressor Effect Produced by Stimulating the Central End of the Sciatic of a Curarized Cat Under Morphine. Time tracing in seconds. Reduced one-half.

The complicated nervous mechanisms thus associated with the circulatory apparatus enable the nervous system, directed by the afferent impulses which reach it along various channels, to coordinate the action of the heart and vessels and to direct the blood flow according to the needs of the body. The blood supply of the organs is continually shifting according to their varying activity; but dilatation and increased blood flow to the active organs is met by compensatory constriction elsewhere, thus preventing a wasteful use of cardiac energy which would otherwise be required to keep up the general blood pressure. This reciprocal relation is particularly conspicuous between the blood-vessels of the somatic and those of the splanchnic divisions of the body, thereby providing the chief means by which the blood pressure is regulated and by which the maintenance of a normal body temperature is in large measure secured.

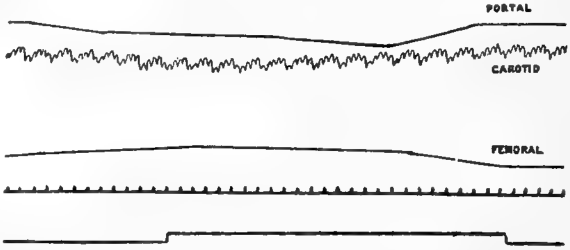

FIG. 1360.—Dog. Ether. Vagi intact. Fall of pressure in carotid and portal vein, and rise in femoral vein on stimulation of sciatic at 10°. All the curves have the same base line; the curves of venous pressure being drawn to indicate the pressure in millimetres Na_2CO_3, the curve of arterial pressure in millimetres Hg. The changes of pressure in the curves must be multiplied by two to obtain the absolute changes. Tracing from right to left.

George P. Dreyer.

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CIRCULATION, PATHOLOGY OF.—The state of the circulation is dependent upon the work of the heart, the condition of the blood-vessels, and the amount and character of the blood. Through the rhythmical contractions of the auricles and ventricles the blood is kept in motion within the vessels, where it flows under a certain pressure which is dependent upon the elasticity of the vessel walls and the amount of peripheral resistance. This pressure is relatively high throughout the systemic arterial circulation, but is low in the veins. The venous pressure, however, varies with the location of the vein, being greatest where the vessel supports a high column of blood. In the great veins of the thorax the pressure is very slight, or negative during inspiration when the negative pressure within the thorax causes an aspiration of the blood from the veins outside of the thoracic cavity. In forced expiration the pressure within both thoracic and systemic veins is increased. The factors directly controlling the blood pressure are: the mass of blood, the work of the heart, and the resistance of the blood-vessels. The latter factor is chiefly dependent upon the degree of tension exerted by the elastic contractile vessel walls. In the systemic circulation the tension is normally much greater than that in the pulmonary vessels; the pressure in the pulmonary artery being only about one-third of that in the aorta. The work of the heart is governed by the condition of its muscle and ganglia, and of the nerves and centres regulating its action. The blood-vessels are also under nervous control, and the circulatory conditions are influenced to a large extent by this innervation as well as by changes in the walls themselves. Every lesion of the heart or blood-vessels, as well as any disturbance of the nervous mechanism controlling the blood flow, will be followed by pathological disturbances in the circulation in case such lesions are not compensated by increased work of other parts of the circulatory apparatus. Further, the tone of the heart muscle and blood-vessels as well as that of the ganglia and nerve centres is directly affected by pathological changes in the amount or composition of the blood; therefore the pathological states of the circulation arise as the result of those pathological changes which lead either to disturbances of heart or blood-vessel function or to an altered state of the blood. These may be considered in the following order:

Increase of Heart's Action.—An increase in the rate of the heart's contractions without decrease in force causes an increased velocity of the blood flow with rise of arterial pressure. The force of each beat may or may not be increased at the same time, or it may be strengthened without change in the rate. The effect upon the circulation is the same at first in both cases. As a result of increased muscular activity the heart undergoes a compensatory hypertrophy in case its nutrition is properly kept up. When both rate and force are increased the compensatory reserve of the heart muscle is sooner exhausted, as the short diastoles lead to fatigue, the products of waste are not thoroughly removed, and the nutrition of the muscle suffers. As a result fatty degeneration may take place, and with this a failure of compensation. As long as the nutrition of the muscle is kept up to meet the increased demand compensation will be maintained. The left ventricle is the first to become hypertrophic, but as the right ventricle receives a larger amount of blood during diastole because of the quickening of the blood current its muscle has also an increased amount of work to perform and likewise becomes enlarged. The increased work of the heart may be caused by excessive bodily labor, over-exercise ("athletic heart"), high living, abnormal irritability of the cardiac nerves ("smoker's heart," "sexual heart,"), etc. Obstruction to the outflow of blood from the heart or in the aorta, abnormal positions of spine or thorax, chronic nephritis, etc., may also be accompanied by increase in rate and strength of the heart's action. In all of these conditions when compensation is fully maintained the pulse is full, quick, and of high tension. The heart sounds are increased in force, especially the aortic second sound. The first sound at the apex is frequently accompanied by a soft blowing murmur even when compensation appears to be perfect.

Impairment of Heart's Action.—The efficiency of the work of the heart may be impaired by pathological changes in the heart muscle: anæmic infarction, fatty degeneration and infiltration, atrophy, coagulation necrosis, myocarditis, etc. In the acute infectious fevers and in many of the intoxications, trophic disturbances, prolonged over-work, etc., the heart may become inadequate without discoverable anatomical changes. Obstruction of the coronary vessels may lead to heart failure so rapidly that the anatomical changes produced may be too slight to be recognized. Likewise in the acute heart failure resulting from a sudden over-strain no microscopical changes may be found in the heart muscle. Pericardial and pleural adhesions and effusions, deformities of the thorax, thoracic tumors, aneurisms, high position of the diaphragm, etc., may hinder the filling of the heart during diastole, so that the blood becomes dammed back in the venous system while a less amount is supplied to the aorta. Pericardial adhesions may also hinder the amplitude of the systole. Stenosis and insufficiency of the valves of the heart are the most common and important causes of impaired heart's action. In stenosis of any valvular orifice the onward flow of blood is impeded; in insufficiency of the mitral and tricuspid the ventricular systole forces blood back into the auricles, and in pulmonary and aortic insufficiency there is during diastole a backward flow into the ventricles. Valvular vegetations, thrombi either free or situated upon the valves or between the trabeculæ of the heart muscle, may interfere with the free passage of the blood through the heart.

The effects of impairment of cardiac efficiency are in all cases the same: there is a decreased amount of blood supplied to the arteries, and an over-filling of the veins. This leads to a fall in arterial pressure, while the venous pressure rises. As a result of the engorgement of the veins and capillaries, the surface of the body becomes cyanotic, and stagnation œdema may occur. If the difference between arterial and venous pressure reaches a certain minimum, stasis results. When the cause of impaired efficiency is located in the left side of the heart there is first manifested an over-filling of the pulmonary circulation. This leads to increased work on the part of the right ventricle resulting in compensatory hypertrophy. When the cause is located on the right side the blood is dammed back into the systemic veins, while in the aorta and pulmonary circulation there is a fall of pressure and diminished supply of blood. The damming back of the venous blood into the large thoracic veins may cause an exaggeration of the normal venous pulse (negative venous pulse) in these veins, and in case the vessels are so distended that the valves of the jugular bulb become inadequate this pulse may extend beyond the bulb into the veins of the neck and head. It is presystolic in time, occurring synchronously with the auricular systole. If the dilatation of the right side of the heart becomes so great that the tricuspid valves are rendered inadequate, or if an organic insufficiency of these valves is present, a second venous pulsation (positive venous pulse) may be produced. This is systolic in time, being caused by a backward flow of blood through the tricuspid opening during the contraction of the right ventricle. The extreme engorgement of the veins in tricuspid insufficiency may lead to pulsations of the liver, which may become greatly enlarged from the over-filling of the hepatic veins.

In all conditions in which the contractions of the heart become infrequent and weakened, the arterial pulse is slow, soft, and small in volume. Such a pulse wave ("pulsus tardus") is seen in aortic stenosis. In insufficiency of the aorta or pulmonary artery a normal, or, as is usually the case, an increased amount of blood is thrown into the artery during systole, while in diastole a partial regurgitation into the ventricles occurs. This causes a sudden fall of tension in the artery which in aortic insufficiency is manifested in the so-called "water-hammer" pulse ("pulsus celer"). The sudden increase of pressure from the excess of blood thrown into the aorta causes a dilatation of the whole arterial system, and also of the capillaries, which may show marked pulsation. In all forms of valvular lesions that part of the heart which is called upon for increased work undergoes a compensatory hypertrophy if conditions of nutrition are good. In stenosis of the mitral orifice the chief work falls upon the right ventricle, which becomes hypertrophied; in mitral insufficiency there is also hypertrophy of the left ventricle, caused by the increased amount of blood which comes to it from the greater flow sent through the lungs by the right ventricle. In stenosis of the pulmonary and aortic orifices the corresponding ventricle becomes enlarged. Since the auricles have but little power of hypertrophy, lesions of the tricuspid valve are most unfavorable inasmuch as they cannot be compensated. In any form of valvular disease compensation becomes inadequate as soon as the heart is driven to the point of fatigue; that is, as soon as the period of diastole becomes so shortened that the products of tissue metabolism cannot be removed and the building-up of the muscle take place in the proper degree. Besides the alterations in the circulation manifested by the pulse, valvular lesions give rise to marked changes in the sounds of the heart, pathological sounds (murmurs) of varying quality and intensity being produced.

Disturbances of Blood Pressure.—The blood pressure in both the systemic and pulmonary arteries varies within certain physiological limits. Through the influence of many widely differing pathological conditions these limits may be over-stepped, and an abnormal increase or diminution of arterial pressure may result. Increase of pressure in the aorta may be due to an obstruction in the aorta or in the larger arterial branches, or to vascular contraction involving the entire corporeal circulation or vascular areas large enough to affect the entire circulation. Increased aortic resistance may be caused by stenosis of any portion of the vessel, congenital hypoplasia of the entire aorta or of a portion of its course, aortic thrombosis, aneurism, changes in its wall due to arteriosclerosis and inflammation, or to dilatation of its lumen due to loss of elasticity of its walls following sclerotic changes. Contraction of the peripheral arterioles with resulting increase of pressure in the aorta may be caused by an excess of carbonic acid in the blood. In chronic nephritis there is a permanent increase in the general arterial pressure, the cause of which is as yet uncertain. It may be due to the direct action of retained urinary poisons upon the blood-vessel walls, or upon the vaso-motor centres, or to reflex stimulation of the vessels or heart. In whatever way it may be caused, the increase of arterial pressure has been conclusively shown to be due to increased peripheral resistance resulting from the contraction of the smaller arterioles. As a result of this increased resistance the heart undergoes a compensatory hypertrophy. It is possible, however, that the enlargement of the heart, in part at least, may be due to an increased stimulation of the heart itself. Chronic intoxications from various poisons as lead, ergot, etc., likewise lead to increased arterial pressure, which may be due either to the direct effect of the poison upon the vessel wall or nerves or to changes in the kidneys.

Arterial pressure in the systemic circulation may be diminished by severe hemorrhage, relaxation of arterial tone following paralysis of the vaso-motor system, syncope, shock, hysteria, injuries to the cervical cord, etc. When this decrease of pressure occurs, the blood passes too rapidly from the arteries into the veins, the pressure in the two systems tends to become equal, so that when a certain minimum of difference is reached stasis occurs.

Increase of pressure in the pulmonary circulation may be caused by obstruction of a portion of the lung capillaries, inflammatory conditions of the lungs and pleura, atrophy, emphysema, indurations and retractions, pleural adhesions and effusions, thoracic deformities, tumors, aneurisms, etc. When the pulmonary obstruction is but slight, it may be entirely overcome by collateral dilatation; if the obstacle is large enough to cause the pulmonary pressure to rise, compensatory hypertrophy of the right ventricle will follow.

The pulmonary pressure may be decreased as a result of valvular lesions of the right heart, thrombosis, weakness of the muscle of the right heart, etc. A decrease in the negative pressure in the right side of the thorax, caused by pneumothorax, pleural effusions, high position of the diaphragm, etc., hinders the aspiration of blood into the right heart, and causes a general damming back of the venous blood and a deficiency in the pulmonary and arterial systems. If this decrease of negative pressure is very sudden, as in right sided pneumothorax, the blood may flow back out of the right auricle into the veins.

Changes in the tension of the systemic circulation are recognized by the palpation of the radial pulse; those of the pulmonary system by the auscultation of the pulmonary second sound, which varies in strength according to the tension in the pulmonary artery. The clinical value of this sound is so great that it has been called the "pulmonary pulse."

Disturbances of Blood Supply.—The regulation of the amount of blood which an organ or tissue receives under normal conditions is effected by changes in the calibre of the afferent vessels. These changes are primarily dependent upon the elasticity of the vessel wall and the power of contraction possessed by its muscular coats. The latter are controlled by nervous impulses arising from the vessel plexuses or from the vaso-motor centres in the medulla and cord. These impulses may be direct or reflex, and either inhibitory or stimulative in character. As the total amount of blood in the body is not sufficient to fill all of the vessels to their fullest capacity at the same time, it follows that at certain times some of the organs may be richly supplied with blood, while others contain but little. The former condition is designated as hyperæmia, the latter as anæmia. When these conditions become protracted in time or of excessive degree, the hyperæmia or anæmia is to be regarded as pathological.

Hyperæmia.—This may be either active (arterial congestion) or passive (venous congestion). The former depends upon an increase in the arterial supply; the latter is caused by obstruction to the venous outflow.

Arterial congestion may be either collateral or idiopathic. The first plays but a slight rôle pathologically. It is merely the result of a diminished flow to other parts, and is found in the immediate neighborhood of parts whose blood supply has been decreased or entirely shut off, as around an anæmic infarct. An active hyperæmia of the internal organs may be caused by a contraction of the peripheral vessels as in a chill. In carbonic monoxide poisoning more than half of the volume of blood may be gathered in the blood-vessels of the abdominal cavity. Idiopathic active congestion is of much greater pathological importance. It depends upon a dilatation of the vessel, due either to paralysis of the vaso-constrictors, stimulation of the vaso-dilators, direct action upon the muscular coats, or a lessening of the external pressure exerted upon the vessels. Neuro-paralytic congestion may be caused by injury or section of the cervical sympathetic; as in a case of gunshot wound of the right cervical sympathetic, unilateral flushings of the face were caused by slight exertions. The unilateral congestions in migraine and various forms of neuralgias may also belong to this class; likewise the phenomena observed in shock, where paralysis of the splanchnic leads to an extreme active congestion of the abdominal vessels. Many of the local hyperæmias common in hysterical cases may also be explained as being of the nature of neurotic congestions, but between the paralytic form and that due to stimulation of the vaso-dilators no clear line can yet be drawn except in experimental work. Direct weakening of the muscles of the blood-vessel walls may be caused by the action of heat, trauma, disturbances of blood current, action of certain drugs, as atropine, chlorine, ammonia, etc. Active congestion of the abdominal vessels follows the removal of ascitic fluid; likewise, in stenosis of the upper respiratory tract, the decreased pressure in the alveoli of the lungs leads to active dilatation of the pulmonary arterioles and capillaries. Active congestion is manifested clinically by redness, swelling, and increased warmth of the affected area.

The color is that of arterial blood. The clinical picture resembles that of inflammation, in which process active congestion plays a very important rôle.

Passive hyperæmia may be produced throughout the entire systemic venous circulation as the result of imperfect compensation of valvular lesions, impaired efficiency of the cardiac muscle (fatty degeneration and infiltration), obstructions in the pulmonary vessels, decreased negative pressure in the right half of the thorax due to pleuritic exudates, etc. Lesions in the right side of the heart produce a direct damming back of the venous blood; those in the left side cause first a passive congestion of the lungs which, if not compensated by the right ventricle, will extend back through the right heart into the veins of the corporeal circulation.

Local venous hyperæmia may be caused by compression, ligation, direct pressure upon the vein by tumor or pregnant uterus, venous thrombosis, extension of malignant growths into the lumen of the vein, gummata, etc. In cirrhosis of the liver the obliteration of the intrahepatic branches of the portal leads to chronic passive congestion of all the branches making up the portal together with their collaterals (caput medusæ, œsophageal hemorrhoids, etc.). Pressure upon the superior vena cava by mediastinal tumors leads to a dilatation of the superficial veins of the thorax and abdomen from the establishment of a collateral venous circulation through these branches. The flow of blood from the lower extremities may be retarded by lack of proper aid from muscular action, as in the case of varicose veins in individuals who lead sedentary lives or who stand in one position for a great part of the time. This form of congestion is also favored by the anatomical peculiarities of certain veins: the hemorrhoidal, for example, containing no valves, are easily affected by disturbances of the venous circulation through the liver, since the blood from these vessels is obliged to traverse a second set of capillaries in this organ. Hemorrhoids are on this account one of the earliest symptoms of hepatic obstruction. The branches of the left spermatic vein are also predisposed to passive congestion, from the fact that this vessel empties at right angles into the left renal vein.

The obstruction to the flow of blood in any single vein is usually of slight consequence if the vessel has free anastomosis with other veins, but if the collateral circulation is insufficient partial or complete stasis must result which may lead to thrombosis. Frequently the dilatations of the veins behind the point of obstruction may overcome this, and the flow become re-established, or the small anastomosing veins may become stretched until they are adequate to carry on the obstructed circulation. In this way small veins may become changed into vessels of large size. Even after thrombosis the lumen of the vein may be partly restored by contraction of the thrombus and formation of new channels in the tissue resulting from the organization of the thrombus. The contraction of this newly formed tissue also aids in the formation of new blood channels. Direct anastomosis between veins and arteries may also occur.

The clinical signs of passive congestion are most manifest in the extremities, tips of fingers, ears, and nose. When the congestion extends into the capillaries, the tissues acquire a reddish-blue color (cyanosis), become somewhat swollen, inelastic, and warmer to the touch. In thrombosis of either the superior or inferior vena cava the corresponding half of the body supplying these vessels becomes cyanotic. Enlargement of the liver, venous pulsations, stagnation œdema, etc., are important clinical features of general venous congestion. Both active and passive hyperæmia may disappear after death. The contraction of the vessel walls in rigor mortis forces the blood out of the smaller vessels into the large veins and auricles. Extreme passive congestion usually persists to a greater or less extent after death.

Hypostasis (*Cadaveric Lividity*).—After death the blood in the arteries is driven into the veins by the contraction of the arterial walls, so that within a short time after the beginning of rigor mortis the entire mass of blood is found in the veins and auricles, while the arteries and ventricles are contracted and empty. The blood thus collected in the veins tends, through gravity, to sink to the dependent portions of the cadaver, so that within a few hours after death reddish or bluish patches of coloration appear over these parts. If the body lies in the usual position upon its back, those portions of the back not pressed upon by the weight of the body become hypostatic. In a cadaver kept in an upright position the hypostasis would be confined to the lower extremities. Post-mortem hypostasis is more marked in those cases in which there has been a general passive congestion before death. Pressure upon the hypostatic areas causes them to become pale, and cutting into them with a knife produces hemorrhage from the dilated veins. In carbon monoxide poisoning the hypostatic areas are of a bright cherry-red color; in poisoning by potassium chlorate they are of a dirty chocolate brown. Post-mortem hypostasis also appears in the internal organs, to the most marked degree in the lungs and meninges. In these regions it is often mistaken at the autopsy for pathological conditions. Ante-mortem hypostasis of the internal organs, especially of the lungs, may result from weakened heart's action. This is most likely to occur in failure of compensation in chronic valvular disease and in prolonged fevers or severe cachexias. As the force of the blood flow becomes decreased, it is not able to drive the blood ahead with sufficient power to overcome the force of gravity, so that a hyperæmic condition of the lower portions of the lungs is produced which gradually leads to stasis. As a result the circulation is further impeded and death may be hastened.

Increase in the Volume of Blood.—An increase in the mass of the blood, so that the sum total comes to stand in an abnormally high proportion to the weight of the body, is known as plethora. It is very doubtful if this condition exists as a definite pathological state, but it is possible that as a result of over-eating and drinking or as a part of some diathesis there may be a temporary increase in the total mass of the blood. In such cases there is a compensatory hypertrophy of the heart and a dilatation of the arteries. As a result of the high tension and consequent overstretching of the vessels, early sclerotic changes may result. The metabolic powers of the body are in time decreased by excesses in eating and drinking, and with the deposit of a large amount of fat throughout the body the blood tends to become anæmic. Animal experiments show that an increase in the volume of the blood through injection of blood or normal salt solution produces only temporary changes in the circulation. The blood pressure quickly returns to its normal point as a result of the compensatory dilatation of certain vascular areas, especially of the abdominal vessels, and also because of the increased elimination of fluid through the kidney and intestine. Even when the volume of the blood is increased eighty per cent. the plethora is but temporary.

Anæmia.—A diminution in the total amount of the blood leads to marked disturbances in the circulatory system, which are in direct proportion to the amount of blood lost and to the rapidity of the loss. A sudden hemorrhage of 0.5 kgm. in the adult will cause syncope. The blood pressure becomes greatly reduced, the pulse becomes small, fluttering, and frequent, owing to the lessened stimulation of the vagus. The peripheral vessels are contracted, the skin becomes pale and cold, while in the abdominal vessels there is usually dilatation, *i.e.*, hyperæmia. This may lead to stasis as a result of the weakened heart's action. As soon as the amount of blood sent from the heart becomes too small to supply the respiratory centres in the medulla, symptoms of asphyxia appear, and death finally takes place. This may result when less than one-half of the normal amount of the blood in the body is lost if there is a sudden anæmia of the nerve centres. The loss of much larger amounts may be borne if the hemorrhage is extended over a long period of time. When the loss of blood is not excessive, the stimulation of the vaso-motor centre through local anæmia leads to contraction of the vessels, through which means the pressure is gradually raised. The fluid mass of the blood is quickly replaced by absorption of the tissue fluids through the activity of the cells of the blood-vessel walls. After a longer period of time complete regeneration of the corpuscular elements takes place. In anhydræmia caused by the sudden removal of large quantities of fluid from the body, as in excessive diarrhœas, etc., the effects upon the circulation are practically the same as those resulting from hemorrhage. In chronic anæmias due to long-continued decrease in the mass of the blood, blood pressure is lowered and the heart beat slowed. The circulatory apparatus gradually adapts itself to the new conditions, and both heart and blood-vessels become atrophic. Atrophy and fatty degeneration of all the internal organs also take place. Similar changes take place in the forms of anæmia due to changes in the red cells, hæmoglobin, etc. (see *Anæmia*).

Local anæmia or ischæmia is the result of a diminished flow of blood to certain organs or tissues. The total mass of the blood may be normal, or the local anæmia may be coincident with a general anæmia due to changes in the blood as a whole. Local deprivation of blood supply may be caused by ligation, obstruction, embolism, thrombosis, compression, or disease of the vessel walls, or any cause which may act as an obstruction to the afferent arteries of the parts affected. Collateral local anæmia may also occur, but plays but a slight pathological rôle. Local anæmia may also be of neurotic origin, dependent upon increased resistance due to vaso-motor contraction.

In the anæmic area there results a slowing and diminution of the blood stream, which is directly proportionate to the degree of obstruction of the artery. If the vessel is completely occluded the blood current comes at once to a complete stasis. If the part is well supplied with anastomosing collaterals the anæmia may be compensated by an increased flow through the branches, which eventually become greatly dilated and hypertrophied, so that the restoration of the circulation may be complete. If the anæmic area is supplied by a terminal artery which is poorly supplied with collaterals, the blood of the part beyond the point of obstruction is gradually pressed out by the contraction of the tissues about the vessels until the pressure in the anæmic vessels reaches that of the capillaries or is even less than it, so that a backward flow may take place to a slight extent. This is not sufficient for the nourishment of the affected area, so the tissues thus shut off from nutrition either gradually or quickly die. The parenchymatous cells first undergo necrosis, later the endothelium and connective-tissue cells. Such a dead area is spoken of as an anæmic infarct.

If the obstructed artery is supplied with collaterals, the blood pressure in the vessel beyond the obstruction after sinking to a certain minimum will rise again because of the afflux of blood from the collateral veins and capillaries. If these are capable of dilatation, as is frequently the case under normal conditions, the nutrition of the part may not suffer and no anæmic necrosis follow. For this reason the obstruction of a terminal artery in the lung or in the mesentery will not, under normal conditions, lead to infarction; but if the circulation in these regions is already so disturbed that the collateral anastomosis does not yield sufficient nutrition to the part, death will result. Since the blood-vessels under these circumstances contain a greater or less amount of blood, the damage to the vessel walls leads to escape of the blood either by diapedesis or rupture. The necrotic tissue then becomes infiltrated with blood, and the area thus affected is known as a hemorrhagic infarct. The latter is in fact only an anæmic infarct which has become infiltrated with blood which comes into the damaged area from neighboring collaterals. Anæmic infarcts occur in the brain, heart, liver, spleen, kidneys, and muscles; hemorrhagic infarcts only in the lungs and mesentery.

About the periphery of the anæmic infarct there is always seen a narrow zone of hemorrhage and congestion. This is in reality a narrow line of hemorrhagic infarct surrounding the anæmic area, and is produced by the limited collateral anastomosis. To the naked eye all anæmic tissues appear pale. They are also softer than normal, and the color proper of the tissue is more distinctly brought out. An anæmic infarct is grayish or yellowish in color, and cheesy in consistence. In the early stage it is elevated and outlined by a narrow zone of bright red. Later the necrosed area becomes contracted from the absorption or organization of the infarct. Through the contraction of the newly formed tissue deep fissures or grooves may be formed in the surface of the organ. The fresh hemorrhagic infarct of the lungs is dark red, elevated, and firm; later it becomes brown and undergoes softening and shrinking. Since the tissues are dead in both conditions the sequelæ of both anæmic and hemorrhagic infarctions are the same as those of necrotic tissue in general: absorption, organization, sequestration, calcification, etc. Obstruction to the venous outflow produces a damming back of blood, which may be followed by extensive and destructive extravasations. The term hemorrhagic infarct has also been applied to this condition, but it seems best to restrict its use to the anæmic necrosis which is followed by hemorrhage, and to classify this condition under hemorrhage. The rapidity and completeness of the development of a collateral circulation after arterial obstruction depend entirely upon the size and distensibility of the collateral branches. In some cases small capillaries or arterioles become changed in a few weeks to large-sized vessels.

Changes in Current.—As a result of varying conditions in and around the blood-vessels, retrograde currents may at times be produced. These occur most frequently in those veins subjected to pressure resulting from muscular activity. Removal of abnormal pressure by the withdrawal of pleuritic and peritoneal effusions, decrease in the intrathoracic pressure, etc., may cause a reversed current in the large veins near the heart. Compression, ligation, and obstruction of the veins from any cause may lead temporarily to the production of abnormal currents. Collateral local hyperæmia may have the same effect. Such abnormal currents play an important part in the retrograde metastasis of tumor cells and infective emboli. Eddies are also occasionally set up in the veins at the point where a rapid current from one branch is mingled with a slow one coming from another. As these currents of different velocities come together eddies are formed which may favor the formation of a thrombus.

With the slowing of the blood current in any vessel the difference between the peripheral and axial zones of the stream becomes less and less distinct. When a certain degree of slowing is reached, the red cells pass into the peripheral stream and this difference is lost altogether. A clot formed on the vessel wall under such conditions will be composed chiefly of red cells. If the current is but slightly slowed, the peripheral stream contains only leucocytes, and a thrombus formed upon the wall under these conditions will be composed only of fibrin, blood plates, and leucocytes. Alternations in the velocity of the current will lead to the formation of laminated thrombi. However, such changes in current do not always in themselves lead to the production of thrombosis.

Stasis.—This term should be applied to the complete stoppage of the blood current. This may take place either when the vessels are full of blood or when they are empty; hence we may distinguish an anæmic and a hyperæmic stasis. In the former the vessel is collapsed and the red cells are not crowded together. Such stoppage may occur in collateral anæmia or in a general or local anæmia due to any cause. Hyperæmic stasis is more common and is subsequent to excessive hyperæmia, in which the red cells are forced into the vessels under such great pressure that their outlines cannot be made out. The dilated vessel appears as if filled with a homogeneous scarlet mass. If the obstruction is removed before coagulation takes place, the red cells become separated and the circulation is restored. If the stoppage is of long duration, thrombosis takes place. Stasis is also produced by evaporation (exposure of the intestines during laparotomy), heat, cold, alcohol, chloroform, concentrated sugar and salt solutions, or any substance which has the power of quickly abstracting fluid from the blood, injuring the vessel wall, or causing destruction of the blood corpuscles. As a result of stasis a gangrenous necrosis of the affected part may take place.

Coagulation.—Sooner or later after death the blood in the vessels and heart undergoes coagulation. As this usually takes place when the red cells are uniformly distributed throughout the blood, a red clot is formed (cruor, currant-jelly clot, post-mortem clot). In leukæmic blood the post-mortem jelly clot may be yellowish or grayish throughout, having an appearance like that of pus. In the heart and in the large veins the red cells may settle to the lower side of the vessel before coagulation takes place, so that after clotting, the upper layer of the clot, which may contain but few red cells, has a yellowish or grayish appearance (post-mortem mixed clot). Ante-mortem clots are also formed in cases of slow death, where there is a gradually progressive heart failure. These form only in the peripheral stream of the heart and larger vessels, chiefly in the auricles and venæ cavæ. They contain, therefore, few red cells and have a grayish or yellowish appearance. The greater the number of leucocytes contained in the clot the more yellow its color. Toward the axial stream the clot may contain red cells; or when the current is greatly slowed, or there are alterations of rapid and slow velocity, the ante-mortem clot may be mixed or laminated. Such clots are not infrequently mistaken at autopsy for thrombi. They can be distinguished from these by their consistence, size, position, and the fact that they are nowhere adherent to the vessel wall. Coagulation of extravasated blood may also take place either in the tissues or in any of the body cavities. Such clots are usually red, but may be mixed as a result of the settling of the red cells before coagulation begins.

Thrombosis.—If coagulation takes place within the heart or vessels during life as a result of changes in the vessel wall, in the blood current, or in the quality of the blood the process is known as thrombosis, and the resulting clot a thrombus. The first stage of the process consists in the deposit of blood plates upon the intima at the point of injury. These become fused into a granular mass, leucocytes collect and are included in the blood-plate mass, and finally stringy fibrin is deposited. If the blood current is strong and the thrombus does not extend into the axial stream, a white thrombus will be formed, composed only of hyaline and stringy fibrin with a greater or less number of leucocytes. If the current is very slow, a red thrombus results through the inclusion of red cells, which with the slowing of the current pass into the peripheral stream; or, if there are alterations of velocity, laminated thrombi may be formed.

The causes of thrombosis are to be referred primarily to changes in the vessel wall: arteriosclerosis, fatty degeneration, calcification, inflammation, necrotic processes, the various changes in the vessel wall produced by the infections and intoxications, direct injury, etc. Impaired efficiency of heart's action from any cause, dilatation, compression, or stricture of the vessels may also lead to thrombosis. Further, changes in the blood, as in superficial burns, intoxications, anæmia, cachexia, etc., favor coagulation.

The sequelæ of thrombosis are: contraction, simple softening, absorption, purulent softening, organization, or calcification. Embolism may result if the thrombus becomes dislodged and is carried away with the blood current. Obturation of a terminal artery by thrombosis leads either to hemorrhagic or anæmic infarction. Thrombosis of veins produces venous stasis, hemorrhage, etc. The most favorable sequela is organization, the most unfavorable purulent softening, since this leads to the metastasis of emboli containing pus organisms.

Embolism.—The dislodging of a portion of a thrombus or ante-mortem clot and its metastasis by the blood current to other parts of the vascular system where it is unable to pass the lumen is called embolism, and the portion of clot transported is called an embolus. This will have the same structure as the parent thrombus; but after lodgment in a vessel a secondary thrombus of different structure may be formed upon the embolus. The sequelæ of embolism are essentially the same as those of thrombosis. Metastasis may take place either in the direction of the current (direct) or in the reversed direction (retrograde), or the embolus may pass from the venous to the arterial system through a patent foramen ovale or ductus Botalli (paradoxical or crossed embolism).

Hemorrhage.—Any escape of blood from the vascular system is styled a hemorrhage. This may take place either by rupture (rhexis) or by diapedesis. In the latter form the constituents of the blood pass through the vessel walls without appreciable lesion of the latter. Hemorrhage from arteries occurs by rhexis only, from veins and capillaries by both rhexis and diapedesis. The size of the hemorrhage bears no distinct relation to the manner of escape. Large hemorrhages may be caused by either rhexis or diapedesis. The causes of hemorrhage by rhexis are: mechanical injury, diseased conditions of vessel wall, increase of intravascular pressure, and decrease of external pressure. In the arteries changes of pressure are not in themselves sufficient to cause hemorrhage, but in the small veins and capillaries marked disturbances of pressure may lead to rupture. Diapedesis is caused by an increased permeability of the vessel wall in association with a rise of pressure in the veins. Passive hyperæmia, stasis, mechanical, thermal, and chemical lesions of the walls, disturbances of nutrition, etc., may all lead to diapedesis. Neurotic diapedesis also occurs in connection with disturbances of the vaso-motor system, arising either from the central nervous system, lesion of the conducting nerve fibres, or reflexly. Vicarious menstruation, stigmatization, etc., are to be included in this class. A tendency to hemorrhage is called hæmophilia; this may be either congenital or acquired. The former is an inherited condition, the pathology of which is unknown. Acquired hæmophilia occurs in all forms of severe infections, in the various purpuras, in disease of the blood, in many intoxications, etc. The sequelæ of hemorrhage are anæmia which is directly proportionate to the amount of blood lost, absorption or organization of the extravasate, formation of hæmatoidin and hæmosiderin from the broken-down hæmoglobin, etc.

Œdema.—The fluid of the tissues (lymph) is essentially a secretion of the cells of the blood-vessel walls. When the amount of this fluid is increased to an abnormal degree so that the tissue spaces are over-filled with it, the resulting condition is known as œdema (dropsy, hydrops). This pathological increase of the lymph is in all cases chiefly due to an increased activity of the secretory cells of the vessels. This is shown by the fact that the fluid of œdema contains less albumin and frequently more extractives than the blood, that its chemical nature in different portions of the body differs, and that its production is under nervous control. Further, the specific function of the capillary walls may be excited by injection of certain substances, hypnotic suggestion, etc. The accumulation of the vascular secretion in the tissues may be due to stagnation of the blood stream, obstruction to the outflow of lymph, pathological alterations in the walls of the capillaries altering their secretion, and stimulation of the vascular secretion by decrease of the pressure external to the vessels (*œdema ex vacuo*). Under ordinary conditions neither stagnation of the blood nor obstruction to the outflow of lymph is sufficient in itself to cause œdema; but in the first case it is probable that the high pressure stimulates the vessel walls to increased activity. The pathological changes in the walls of the capillaries and veins leading to increased vascular secretion may be either toxic, infectious, mechanical, thermal, nutritional, or nervous in origin. Clinically the following varieties of œdema are described: stagnation, inflammatory, hydræmic, cachectic, and neuropathic. The fluid of inflammatory œdema contains more albumin, and is probably partly derived from the direct escape of the blood constituents. It may be collateral, occurring in the neighborhood of inflammations.

Hydræmia only favors the production of œdema, but does not in itself cause it. The œdema of nephritis is more probably due to the changes in the vessel walls, caused by the alterations in the blood. The œdema of anæmia may be explained in the same way. Œdema ex vacuo occurs chiefly in the central nervous system following a loss of a part of the nerve tissue. The local defect becomes filled with fluid resembling in character that of the cerebro-spinal fluid. It is produced by an increased secretion from the capillaries which is probably caused by the decreased pressure around the vessels. Œdematous tissue is swollen, boggy, inelastic, and pits when pressed upon by the finger. Extensive œdema of the skin and subcutaneous tissues is known as anasarca or hyposarca. When the condition is very extreme rupture of the skin may take place and the fluid escape. Incision or trocar puncture may be of service in allowing escape of the fluid. Collections of fluid in the thorax (hydrothorax) and peritoneal cavity (ascites) may be removed by tapping.

Disturbances of Lymphatic Circulation.—The lymphatic circulation through the thoracic duct or larger lymph vessels may be obstructed by pressure from tumors, inflammations, invasion of lumen by new growths, etc. Local œdemas may result, but this is not always the case even when the thoracic duct is obstructed, as the lymph vessels have elaborate anastomoses, and collateral channels may be opened which suffice to carry off the excess of the lymph. Obstruction of large lymph trunks will, however, increase an œdema already resulting from excessive vascular secretion. Escape of lymph (lymphorrhagia) is caused by interruption of the continuity of a large lymphatic. Since the pressure in the lymphatic circulation is practically the same as that of the tissues, lymphorrhagia can take place only from a surface, either externally or in a body cavity. The escape may be checked by very slight pressure. Rupture of the thoracic duct is the most important and dangerous. It is usually traumatic in origin, but may be the result of inflammatory processes involving the duct, or it may be caused by obstruction or compression of the duct by tumors. As a result of such a lesion lymph may be poured out into the thoracic or abdominal cavity (chylous hydrothorax, chylous ascites, etc.). If the opening in the lymphatic vessel is permanent, a lymph fistula may result from which there is a permanent oozing of lymph. In this way large quantities of fluid may be lost and serious disturbances of nutrition may result.

Chyle may also appear in the urine as a result of obstruction of the abdominal lymphatics, which in turn leads to dilatation of the lymphatics of the bladder wall. From the rupture of the latter chyle escapes and becomes mingled with the urine. Chyluria is associated with the presence of the filaria sanguinis; but the exact relations between the parasite and the changes leading to chyluria have not as yet been satisfactorily cleared up. Metastasis of tumor cells, micro-organisms, etc., also takes place through the lymph channels (lymphogenous metastasis), and may be either direct or retrograde. The latter plays a very important rôle in the metastasis of carcinoma. (See *Coagulation, Embolism, Hæmorrhage, Œdema, Thrombosis*, etc.)

Aldred Scott Warthin.

CIRCUMCISION.—(Synonyms: Posthectomy; Lat., *Circumcisio;* Fr., *Circoncision;* Ger., *Beschneidung.*) Circumcision is the partial or complete removal of the prepuce or foreskin. The operation is performed as a religious rite, and as a hygienic or therapeutic measure in congenital or acquired phimosis and in some other diseases of the prepuce and penis. Among females in Arabia, Egypt, Nubia, and some other portions of Asia and Africa, travellers have observed a similar custom, consisting of amputation of the labia minora or mutilation of the clitoris.

As a religious rite, circumcision is a practice of great antiquity and geographical extent. While most commonly performed among the Hebrews and Arabians, it is frequently observed by travellers in other portions of Asia and Africa where the origin of the custom is easily traced, and it is also seen in parts of South America, in the islands of the Pacific Ocean, in Madagascar, and in other places where no clue to its origin has yet been discovered. The Hebrews are supposed to have derived their knowledge of circumcision from the Arabians or Egyptians, most probably the latter, among whom the practice originated, according to Herodotus. An interesting account of the operation as performed in Algiers is given by Tarneau, in *Gazette des Hôpitaux*, 1855, and referred to by Hamdy in his monograph on circumcision, which also gives much valuable information of the history of the operation (Hamdy, "De la circoncision"). The age at which the operation is performed varies in different places. The Hebrews operate on the eighth day, as is also done in Algiers, while generally the Arabians wait until the tenth or thirteenth year, the age of puberty. The operation consists essentially of three parts: circular section of the extremity of the prepuce, tearing of the remainder of the prepuce to the corona, and denudation of the glans, and suction of the wound and penis by the operator. Hemorrhage is arrested by styptics, powdered coral, or generally tannin; and simple dressings are applied to prevent the inner layer of the prepuce from again covering the glans penis. As the operation has too frequently been performed by unskilful and dirty hands, serious complications and fatal results have often followed. Cases of death from excessive hemorrhage and inflammation can be found in the literature of the operation, as well as cases of various untoward complications, for example, wounds of the glans penis or urethra. Much has been said, too, of the danger of transmission of syphilis in the disgusting third part of the operation, whether from the operator to the patient, or occasionally from the patient to the operator.

The prepuce consists of two folds of integument, separated by very loose connective tissue, that cover and protect the glans penis. They meet and become continuous at the preputial orifice or end of the foreskin, which is usually the narrowest part of the prepuce, although sufficiently large in adults to allow the prepuce to be retracted so as to expose the glans. At birth the prepuce is longer than the penis, and its orifice narrow, often preventing exposure of the glans, so that a greater or less degree of congenital phimosis is pretty constant. The inner surface of the prepuce at this time embraces the glans closely, especially at the corona where there is generally a little circle of adhesions. Sometimes the prepuce and penis are adherent over a much greater extent of surface, either in little patches at various parts of the glans, or from the corona to the meatus. The adhesions are generally easy to subdue, partaking more of the nature of agglutinations than of firmly organized tissue. They are apt to be the source of local irritation, and to cause the retention of the secretion of the glands of Tyson, or smegma præputii. It occasionally happens that the prepuce is imperforate, a condition that soon makes itself manifest and is easily recognized. The child passes no urine, and a soft, fluctuating, transparent tumor forms slowly on the penis. As the tumor grows it pulls upon the skin of the scrotum and pubes, and an inspection shows that there is no preputial orifice. An incision must be made as soon as possible to allow the escape of urine, but circumcision had better be deferred to a later period, when it may be unnecessary to do more than trim up unsightly flaps. In childhood there are not many changes in the prepuce; the few erections rupture a part of the congenital adhesions. Attacks of balanitis or posthitis may result from the decomposition of retained smegma and give rise to contraction of the preputial orifice, or new adhesions between the prepuce and the glans. A child with phimosis and an unhealthy local condition may have no symptoms, and at puberty, with the changes that occur in the penis, the phimosis may disappear. But if there are dysuria or reflex symptoms arising from the phimosis, operative interference is essential, not only to relieve the immediate trouble, but as a prophylactic against various conditions apparently dependent on it, as varicocele, hernia, some cases of masturbation, etc. (see article *Phimosis*). At puberty the glans increases in size, erections become more frequent and strong, and usually destroy any remaining adhesions, while they dilate the preputial orifice so that the phimosis disappears. If any adhesions still persist they are strong and firm, and may prevent the development of the glans, and be the cause of painful erections, tenderness of the penis, etc., as well as of other symptoms more or less evidently dependent on the local condition. Such a condition is best remedied by circumcision, and, indeed, it is a question of considerable interest and importance whether it is not desirable to perform circumcision at an early age as a hygienic and prophylactic measure. The outer lamella of the prepuce is continuous near the corona glandis with the integument that covers the body of the penis. One should remember the elasticity of this integument and the laxity of its subcutaneous tissue, and avoid undue traction upon it in performing circumcision, or it may happen that when the skin has been drawn forward and amputated, an unexpectedly large surface of the prepuce will be found denuded, or there may be a circular wound near the middle of the penis while the parts covering the glans have entirely escaped the knife. Such an accident is usually a surprise to the operator, and may be followed by disagreeable deformities from subsequent cicatricial contraction. Under the circumstances, the best course to pursue is to relieve the phimosis for which the operation has been undertaken, by a dorsal incision, without removing any more integument, and after careful arrest of hemorrhage to approximate the edges of the circular wound as well as possible by sutures and endeavor to secure primary union. The inner surface of the prepuce is reflected forward from the corona glandis to the orifice of the foreskin. In its ordinary condition, protected from friction, and lubricated by the natural secretions of the part, it is soft, pliable, moist, and so much resembles a mucous surface that it is usually referred to as the "mucous membrane," in distinction from the "skin" or outer layer of the prepuce. This layer, and not the skin, is usually affected in phimosis. The constriction is usually at the meatus, although it may be anywhere between there and the corona. The frænum præputialis is a small triangular fold of the inner layer of the prepuce, is inserted near the meatus of the urethra, and when too short may interfere with retraction of the prepuce, pulling the penis downward and producing pain. On each side of it, near the median line, are the arteries of the frænum. When these are divided in circumcision they may be the source of troublesome hemorrhage; accordingly the operator is directed in most of the text-books to avoid them if possible. Where the frænum is short, it is better to disregard this precept and divide the frænum thoroughly, or remove a portion of it, and be prepared to place fine catgut ligatures on the arteries that bleed.

A considerable number of operative procedures have been suggested and practised by different surgeons, having in view the more accurate removal of the redundant prepuce, and the coaptation of the wound surfaces. They fall into three classes: preliminary incision of the prepuce, dilatation, and amputation of the prepuce without previous incision or dilatation. The preliminary incision is usually made on the dorsum of the prepuce, as far back as the corona, and the two flaps thus formed are carefully trimmed away. The incision may be made with a pair of blunt-pointed scissors or a bistoury. The bistoury may be inserted into the preputial orifice on a director, or the point may be protected by a little lump of wax and the bistoury passed with the side to the glans as far as the corona, then, turning the back to the glans, the point is pushed through the foreskin, which is divided by drawing the bistoury forward. The trimming of the flaps may be facilitated by the use of curved forceps applied so as to leave out the portion that is to be removed. Instead of making this division the prepuce may be dilated and cotton stuffed between the prepuce and penis, but this is a tedious and sometimes impossible process, and has no advantages beyond the greater facility of applying needles and sutures in the prepuce, so as to render the coaptation of the surfaces more accurate. The incision, however, is of great value, especially where there is reason to believe that a constricted prepuce conceals a venereal sore that cannot be disinfected. Here a comparatively small incision allows the sore to be exposed, and after it has been disinfected or has cicatrized, the unsightly flaps may be trimmed off. In such cases it often happens that so much tissue has been destroyed by the ulcerative process that there is no excess of tissue when the wound has healed. The most simple and rapid method of circumcision is by a transverse incision made obliquely from behind forward and above downward, in the direction of the margin of the corona glandis, the glans being carefully protected from the cutting instrument. The prepuce may be drawn forward with the fingers or with forceps, and the glans may be protected by Ricord's forceps or the handles of a pair of scissors or other instrument applied obliquely. To insure division of the prepuce at the proper place, if the eye cannot be trusted, it is well to mark with ink or iodine on the prepuce at the point where the corona glandis underlies in a natural condition of the parts, and to make the section a very little in front of this level. Ricord made the mark two lines from the corona, and after applying forceps transfixed the prepuce with needles along the line so as to secure accurate apposition of the two preputial layers after removing the prepuce. Other surgeons, however, sometimes remove more or less of the two layers. Dieffenbach and Redreau removed all the mucous surface, leaving enough of the outer to cover partially the glans. After the prepuce has been drawn forward and divided, the forceps or other protecting instrument is removed, and the integument slides back on the penis, while the inner layer of the prepuce still covers the glans. This may either be turned back if there is no constriction, or divided as far as the corona by cutting or tearing on the dorsum. The two flaps thus formed may be left or trimmed away; it is generally preferable, with a pair of curved scissors and forceps, to cut away evenly on all sides, leaving about a quarter of an inch. At the same time that this layer is turned back any adhesions are carefully broken, or if firm, cut through, doing as little damage to the penis as possible. All hemorrhage should be carefully arrested, fine catgut ligatures being used for the purpose. The edges of the two layers are then united by fine sutures, which may be either of horsehair, silk, or catgut. A continuous catgut suture is very useful, but if many stitches are used there is apt to be considerable swelling of the parts from the contusion and handling. In young children it is not necessary to use sutures, as the dressing prevents the inner layer from again covering the glans, and retains the parts in sufficiently close apposition for union to take place readily. If silk or horsehair sutures are used they should be removed on the fourth day. Instead of sutures, the parts may be held together by serresfines, but these are apt to fall off as the patient recovers from ether and may excite erections. If they are used they should all be removed by the end of twenty-four hours. Before the operation an attempt should be made to disinfect the parts, and antiseptic dressings should be applied. In children it is impossible to prevent the soiling of the wound by urine, but in adults, with care, pretty thorough asepsis may be preserved. After urine has been passed the wound should be thoroughly cleansed with some disinfecting solution and a new dressing applied. In children, cold-water compresses and weak carbolic acid solutions, or a light dressing of iodoformized gauze are as useful as any elaborate dressing, and may be frequently renewed.

The operation should not be performed without some anæsthetic. For the surgeon's comfort a general anæsthetic is the most satisfactory, but there are many cases in which local anæsthesia may well be employed. Cocaine or eucaine may be used, or Schleich's mixture for producing analgesia (see *Anæsthesia, Local*). With very young children and when older patients are nervous and emotional, it is not wise to use the local analgesia on account of the alarm that is produced by the preparations for and procedures during the operation. On the other hand, in the case of adults, there may be such a complete absence of pain and fright that the patient can himself assist the surgeon in the operation if necessary.

In some cases, especially where there is danger of hemorrhage, the patient suffering from hæmophilia, the écraseur, the galvano-cautery, or caustics have been substituted for the knife or scissors, but they can hardly be recommended.

The operation is liable to be followed by the ordinary diseases of wounds, but as it is frequently performed by unskilful hands, it has perhaps had more serious sequelæ than other equally simple operations. As already stated, it occasionally happens that too much integument is taken away, in consequence of which there are inflammation and suppuration, and finally a contracted cicatrix. Too little integument is more often removed, and the phimosis returns after cicatrization. The glans penis or urethra may be injured, and severe hemorrhages and deforming cicatrices may result. Occasionally, in tearing adhesions, the glans penis is much damaged, with the same result. Severe inflammation, and even death, may be the consequence. Severe and fatal hemorrhage may occur from small vessels of the prepuce or from arteries of the frænum, or from wounds of the glans penis. From various causes the subsequent inflammation and suppuration may be very severe. Jacobi ("Diphtheria") gives a number of cases in which the wound has been the seat of the diphtheritic process in epidemics of diphtheria, and Hueter ("Chirurgie") mentions fatal cases from phlegmonous erysipelas and gangrene. Gangrene of the penis and retention of urine may also result from tight bandages, or from a thread of circular dressings becoming detached and buried in the swollen tissues at the corona. The latter are exceedingly difficult to discover and remove from the tissues, in which they may sink deeply. Retention of urine is usually reflex, and should be relieved by the use of soft catheters. Primary union may fail from infection of the wound with chancroidal virus, the infection usually becoming evident about the third day. Free cauterization is necessary, either with the Paquelin cautery or by means of some of the acids. Excessive inflammation or erections may delay the union of the wound. Erections are very common, and in the swollen and tender condition of the part usually very painful. To prevent them it is well to keep the patient on a low diet, and to prevent constipation. Of drugs, bromide of potassium, lupulin, opium suppositories, suppositories or urethral injections of iodoform, camphor, etc., are used. Union may also be prevented by patients who masturbate, so that the inefficiency of the operation as a cure for that trouble becomes very apparent. The œdema of the parts on the second or third day after the operation is generally due to rough handling during the operation. The clamp may be applied too tightly, or the parts be much contused in placing numerous sutures.

The indications for the operation are, in children, congenital phimosis when accompanied by hydrocele, or hernia, balanitis, preputial calculi, "ballooning" of the prepuce in voiding urine, or by general or special reflex symptoms which may depend upon the local condition, as dysuria, convulsions, epilepsy, spasmodic contractions. In adults the operation is indicated for the same set of troubles as in children, and for phimosis dependent upon inflammation, excited by venereal sores, gonorrhœa, etc., as well as for simply redundant prepuce without phimosis, when there are any local irritation or reflex symptoms, as spermatorrhœa.

The operation should be postponed when the parts are in a condition of acute inflammation, except when there is a sanious discharge from the meatus. In this case, as there is probably a sloughing sore or severe inflammation, the dorsal incision should be first practised to enable local measures to be efficiently applied. The operation should not be done when the patient is known to be a "bleeder," or when very feeble and anæmic, or suffering from febrile or severe constitutional disease, unless, indeed, there may be some very urgent symptoms. Here, generally, the complete circumcision should be deferred and the dorsal incision practised.

It is still a mooted point whether hygiene demands circumcision at an early age. It is certain that many cases of varicocele and hernia are due to the straining in micturition and the handling of the penis by young children. In general, however, congenital phimosis does no harm, and disappears at puberty. On the whole, it seems best to await some local disorder or consecutive trouble, and to urge circumcision at the first sign of local irritation, or when general symptoms appear in connection with a phimosis. *William G. Le Boutillier.*

CIRRHOSIS. See *Liver.* (*Pathological.*)

CITRAL.—($C_{10}H_{16}O$). This is the active constituent of oil of lemon, which contains 7.5 per cent., more than any other oil, though it is found in other fruits of that family and in many other volatile oils of widely different botanical origin. It is a liquid of a yellow color and a specific gravity of about 0.899. It is subject to the same uses as oil of lemon, and may be advantageously substituted for it, in doses about one-tenth as great.

Henry H. Rusby.

CITRIC ACID.—Citric acid, $H_3C_6H_5O_7,H_2O$, is the agreeably flavored acid of lemons and limes, and occurs also in other fruits, such as the cranberry, currant, strawberry, and raspberry. It is official in the United States Pharmacopœia as *Acidum Citricum*, Citric Acid, and occurs in "colorless, translucent, right-rhombic prisms; odorless; having an agreeable, purely acid taste; efflorescent in warm air, and deliquescent when exposed to moist air. Soluble at 15° C. (59° F.), in 0.63 part of water, and in 1.61 parts of alcohol; in about 0.4 part of boiling water, and in 1.43 parts of boiling alcohol, also soluble in 18 parts of ether" (U. S. P.). On heating, citric acid loses its water of crystallization and melts.

Citric acid is the most agreeably flavored of the sour so-called organic acids, and makes, in aqueous solution, a grateful artificial lemon juice. In concentrated solution the acid is irritant, but not corrosive nor specifically poisonous. A six-per-cent. solution of citric acid in water about equals in strength good lemon juice, and if, before solution, a drop or two of the essential oil of lemon be triturated with the crystals, the imitation of genuine lemonade flavor will be quite perfect. Such artificial lemonade can be drunk with the same freedom as the natural article. Taken continuously, and in excess, as in the over-free use of lemons in the tropics, citric acid is capable of producing a peculiarly severe and obstinate form of dyspepsia. The proper dose is from 0.30 to 2 gm. (gr. v.–xx.).

Pharmaceutically, citric acid is of service in the preparation of soluble salts of a number of substances, such as bismuth, iron, quinine, and strychnine. Its principal use is perhaps in the making of the preparations of magnesium citrate.

Several promising commercial experiments in the artificial production of citric acid are now in progress.

Edward Curtis.

CITRONELLA GRASS AND OIL.—*Nard-Grass. Andropogon Nardus* L. (fam. *Gramineæ*). This is a coarse, tufted grass of India, having a delightful lemon-like fragrance. It is used for the distillation of *citronella oil* or *verbena oil.* This is of a very pale yellow color, often greenish from the presence of copper, and having a specific gravity of about 0.895. It consists of citral and a terpene, and is used altogether in perfumery and flavoring.

Henry H. Rusby.

CITROPHEN.—$C_3H_4(OH)(CO,NH,C_6H_4OC_2H_5)_3$. This compound of three paraphenetidin groups with one molecule of citric acid, introduced by Roos, is a white crystalline powder of mildly insipid acid taste. It melts at 181° C. (358° F.), is readily soluble in forty parts of water and in carbonated waters, and is split up by the gastric juice into its components. Paraphenetidin may be detected in the urine by the ferric chloride test twenty minutes after ingestion.

It has been employed with success in dose of 1 gm. (gr. xv.) three times a day to remove the excessive languor and muscular cramps of morphinism. Kronfeld states that it not only reduces temperature, but in rheumatism and the various neuroses it often acts as a specific. In pertussis and chronic morphine poisoning it is without a peer. Kronfeld uses it also with excellent effect in epidemic influenza, and claims that no cardiac depression results from large doses. David Cerna, on the contrary, quotes Treupel as having found it poisonous in large dose. Frieser, Freudenberg, Benario, and others have used it with benefit as an antipyretic in fevers, in typhoid fever, headache, neuralgia, facial neuralgia, neuralgic dysmenorrhœa, migraine, etc. It is sometimes accompanied by sweating. Dose 0.5 to 1 gm. (gr. viij.-xv.), or even 2 gm. (gr. xxx.) three or four times a day.

W. A. Bastedo.

CITRUS.—(*The Orange and Lemon Genus.*) A genus of the family *Aurantiaceæ*, if this be held distinct from the *Rutaceæ*, regarded by Engler as comprising but six species, natives of Southeastern Asia and the neighboring islands, but through long and wide cultivation presenting a great number of varieties and forms which have been regarded as species by various other authors. The great economic value of the edible fruits yielded requires no discussion. The following derivations are accepted by Lyons (Plants' Names, Scientific and Popular) and are probably correctly judged.

The sweet orange from *C. aurantium* L.

The bitter orange from *C. amara* (L.) Lyons.

The lemon, both sweet and sour, together with sweet and sour limes and the citron fruit, from *C. medica* L.; although many authors call the lemon *C. Limonium* Risso, the sweet lime *C. limetta* Risso, the sour lime *C. acida* Pers., and the citron fruit *C. cedra* Gallesio.

The mandarin or Tangerine from *C. nobilis* Lour.

The shaddock, grape fruit, or pomelo from *C. Decumana* Murray.

The bergamot from *C. bergamia* Risso and Poit, probably an artificial hybrid originating under cultivation.

The medicinal importance of the genus is very considerable, although not so great as in the past. The medicinal products of the orange and lemon will be considered under those titles. Only the general characters of the products will be here considered. The medicinal virtues reside in three constituents or classes of them: (1) *Citric Acid*, separately considered; (2) *Bitter Glucosides;* (3) *Volatile Oils.*

The bitter glucosides appear to reside in the inner portions ("white") of the rinds (*aurantiamarin* in oranges, especially the bitter orange, and in citron fruit, and *naringin* in grape fruits or shaddocks) or in the seeds, as *limonin* in the seeds of the lemon. These substances, medicinally, act like ordinary bitters, and like them are irritant and even poisonous in their pure form, especially the naringin of the shaddock.

Hesperidin, $C_{22}H_{26}O_{12}$ (*fide* Merck), occurs in minute white or yellowish crystals and is soluble in dilute alkalies. It splits up into glucose and *hesperetin* ($C_{16}H_{14}O_6$).

Isohesparidin is very similar.

Naringin, ($C_{23}H_{26}O_{12} + 4H_2O$) is in yellow crystals and is soluble in alcohol and in 300 parts of water.

Limonin ($C_{22}H_{26}O_7$?) occurs in minute crystals, and is soluble in alcohol and acetic acid.

Bitter substances also exist in the leaves of these plants, but whether identical with those mentioned above is not known.

The volatile oils in use are derived from the flowers and from the outer portions of the rinds of the fruits. While they possess the ordinary diffusive-stimulant properties of volatile oils in general, they are scarcely used for their medicinal properties, but almost wholly for their flavoring effects. The differences between them pertain almost wholly to the latter uses. Oil of mandarin rind is in use and is practically identical with that of orange. Oil of Bergamot, or Oleum Bergamottæ, is official. It is greenish or greenish yellow and bitter, with a specific gravity of 0.880 to 0.885, and contains limonene, dipentene, linalol, and linaloyl acetate. There is no official preparation.

Volatile oils also exist in the leaves, but these are not employed.

From the above, it is obvious that the Citrus products can be used as simple bitters, as aromatics, or as aromatic bitters, according to whether the constituents are used separately or in a preparation which combines them.

One of the very best of these bitter tonics is the grape fruit, eaten at the beginning of the breakfast, and not too much care should be taken to avoid entirely the bitter portions.

Henry H. Rusby.

CIVET.—A sienna-brown, ointment-like, unpleasantly odorous substance, obtained from two species of *Viverra;* Order *Carnivora, Viverrina.* The first, *Viverra Zibetha* Linn., the Indian civet cat, is from the warmer parts of Asia. The second, *V. civetta* Schreber, the African civet cat, is a native of Africa and Southern Europe. Both are kept in confinement for their peculiar secretion. This is formed in a sac-like gland, situated in front of the anus, in both sexes, between it and the external genitals, and is collected from the domesticated animals, either by saving it as it is discharged, or by scooping it out of the glands with a small spoon, while the animals, closely confined in a small cage in which they cannot turn about, are violently teased. When first gathered, it is semiliquid and brownish yellow, but by keeping it becomes considerably darker and harder. It is a nasty-smelling and dirty-looking substance, usually mixed with hairs and other impurities. Its taste is sharp, bitter, and disgusting. It softens decidedly by warming, and burns with a bright clear flame. The odor, while having a general resemblance to that of musk, is less diffusible and far more disagreeable. Civet is insoluble in water and only slightly soluble in alcohol; not wholly so even in warm ether and chloroform. Its constituents, according to Boutron-Charlard, are *volatile oil*, solid and liquid *fats*, yellow *coloring matter, resin, mucus, ammonia, oxide of iron, and lime and potash salts.*

It is happily no longer used in medicine. Formerly, it had some employment as an antispasmodic in the nervous derangements for which musk has had deservedly greater popularity. It is used for strengthening and fixing perfumes and for scenting bait for game.

W. P. Bolles.

CIVIL INCAPACITY.—What is civil incapacity? Civil incapacity, for the purposes of this article, is the lack of that mental endowment which the law considers an essential element in every business transaction, whether it concerns only the man himself, or those who legally or morally have a claim upon him or upon his property after his death.

Perhaps all of such transactions may fall under one or the other of the following subdivisions: (*a*) contracts; (*b*) deeds; (*c*) wills; (*d*) marriage. For a while the law permits all persons except infants and married women to bind themselves and their property by contract, deed, will, or marriage, as they may choose, yet it throws a protection around the insane and feeble-minded in civil transactions, as it does around the insane and feeble-minded when they are called upon to answer before the courts for the commission of crime. Therefore the law will not permit a sane and healthy-minded man in the guise of legal methods to deprive an insane or feeble-minded man of any property or bind him in any contract or contractual relation. Nor will the law allow the legal heirs or representatives to be deprived of an inheritance by reason of a will which is the product of a diseased mind.

METHODS OF PROOF.

The methods of proof in litigation involving civil incapacity must be ascertained by a careful perusal of discussions or treatises upon expert testimony.

In order to determine such questions, the courts frequently call upon experts in mental diseases to testify before them. However, in this class of cases, as in all other cases, lay testimony is admitted for several purposes.

Where the person whose acts are being construed has previously been adjudged insane, or *non compos mentis*, by a proper judicial proceeding, prior to the transaction in question, this evidence alone will generally suffice, although this may be overcome by evidence of its untrustworthiness or by testimony that since such adjudication, and prior to the transaction, the mind of the person had been restored to a normal condition.

There is rarely any trouble in determining the effect of such transactions when the person whose actions are sought to be avoided is a lunatic or an idiot.

The main trouble is found in cases in which the insanity is partial, when the person suffers from hallucinations and eccentricities or is afflicted with feebleness of mind not so pronounced as to be self-evident to the ordinary mind.

The courts will permit evidence of the following character:

First: The record of former adjudication of other courts that the person was insane, or *non compos mentis.*

Second: The testimony of lay witnesses as to the conduct of the person tending to illustrate the condition of his mind, and even their opinion as to his mental condition, although the courts will receive such opinion evidence with caution and will not give it the weight that is given to the opinion evidence of experts.

Third: Medical experts will be allowed to testify as to facts and conduct as lay witnesses, will be examined by hypothetical questions and asked to express opinions as to the mental status of the person, based on an assumed state of facts. In addition, they will be permitted, after an examination of the person, to give opinions as to his sanity or mental soundness.

As the law makes distinctions between the amount of mental capacity required in different transactions, it is necessary to consider separately the four named: (*a*) contracts; (*b*) deeds; (*c*) wills; (*d*) marriage.

(*a*) *Contracts.*—In order to determine whether a person has sufficient mental capacity to make a contract, it is necessary to consider the definition of a contract. A contract is defined by the most eminent authorities to be "an agreement between two or more persons upon a sufficient consideration, to do, or not to do, a particular thing." The two main features in a contract are first, the consideration; second, the assent—"for there is no contract unless the parties thereto assent, and must assent to the same thing and in the same sense." In other words, sane minds meet upon a common ground.

It is self-evident that mind is the basis of consent, and when the mind is lacking or radically defective, consent cannot arise. Whenever the mind is sufficiently impaired to negative the idea of consent, then the contract is voidable.

The mere superiority of intellect is not a sufficient ground to set aside a contract, no matter how far the stronger-minded contracting party has overreached the weaker. Contracting parties are rarely equal in business shrewdness, and it would be both impracticable and impossible for courts to settle such subtle questions.

In order to invoke successfully judicial interference the mind must be abnormal from disease or mental infirmity, either inborn or subsequently developed. As stated above, the plain cases of insanity and idiocy present no difficulty; the difficulty lies usually where the contracting party was not sufficiently weak-minded as to appear *non compos mentis* to the ordinary and lay mind.

It is difficult to express in one rule the degree of mental capacity of the parties that is required to give binding force to a contract. A competent author has expressed the rule to be that a contract is voidable when made by one who "is so lacking in mental capacity from idiocy, lunacy, senile dementia, or other defect or disease of the mind that he is incapable of understanding what he is doing. To render a person thus incapable of contracting, his infirmity need not be so great as to dethrone his reason nor amount to entire want of reason; but, on the other hand, it must be something more than mere weakness of intellect. It must be such as to render the person incapable of what he is about, or, to be more accurate, of comprehending the subject of the contract and its nature and probable consequences (Clark on "Contracts," pp. 264, 265).

When the proof discloses the fact that the person was not permanently insane, but suffered from occasional fits of insanity, before the contract will be set aside it must appear that the contract was made during one of the fits of insanity.

One of the most peculiar divisions of mental derangement is that which subjects the patient to hallucinations, and the books disclose many notable instances in which men, otherwise liberally endowed and possessed of reason, were the victims of strange fancies to the extent that they were mental hallucinations. Wherever this phase of incapacity is relied upon, the general rule is that if these hallucinations have not taken sufficient hold upon the patient as to impair his entire mental faculties, then it must appear to the court that the contract was the result of the hallucinations, or it will not be disturbed. For while it may be doubted if any person who is afflicted with hallucinations is perfectly sane, yet often in the eye of the law he is insufficiently insane to escape the responsibility of all of his civil or criminal acts.

While the law has never had patience with the plea of drunkenness, and even though the great disciple of the law, Coke, pronounced that it aggravated rather than palliated an offence, yet there are instances where drunkenness will be a sufficient ground to avoid a contract. Before, however, the law will permit a contract to be avoided upon the ground of drunkenness of the complaining party, the drunkenness must have been sufficient to destroy the reasoning power, and to deprive the party of the mental capacity to comprehend the nature and effect of the contract.

After giving this rule, it is almost needless to add that slight intoxication, as a general thing, will not be a ground for relief.

However, the law does not require the intoxication to go to the extent of delirium tremens, for when this state ensues the rules in regard to insanity are applied.

(*b*) *Deeds.*—Deeds are nothing more nor less than executed contracts in reference to the conveyance of land, and the same rules apply to the avoiding of deeds, executed by insane or drunken persons, as to the making of any ordinary contract. And perhaps it may be added that where the deed is voluntary, the same rules are applicable that apply to the contesting of wills. This is especially true where undue influence is exercised over the conveyor.

(*c*) *Wills.*—Public policy deems an equal distribution of one's estate among those dependent upon him by natural ties of great importance, and while it is true that a person not laboring under a legal disability may bequeath his property to whom he pleases, yet the law requires that in order to do this he must be mentally capable as well as legally capable. It is needless to repeat that if the testator was insane, an imbecile, or an idiot, the will, upon proper proceedings, will be set aside. In wills as in contracts, the difficulty presents itself in persons of doubtful mental capacity.

Every man is presumed to have been of testamentary capacity until the contrary is proven. So the burden of proof rests upon the contesting party to prove that the testator did not have testamentary capacity. The question then is, What state of mind does the law regard as sufficient to constitute testamentary capacity?

A careful consideration of the requirements of the law in this regard is made by Mr. Pritchard in his book on "Wills and Administration." He says: "It is essential to the exercise of the testamentary power that the testator should understand the nature of the acts and its effects; should understand the extent of the property of which he is disposing; should be able to comprehend and appreciate the claims to which he ought to give effect; and with a view of the latter object, that no disorder of the mind should poison his affections, pervert his sense of right, or prevent the exercise of his natural faculties; that no insane delusion should influence his mind in disposing of his property and bring about a disposal of it, which, if the mind had been sound, would not have been made. If the human instincts and affections, or the moral sense become perverted by mental disease, if insane suspicion or aversion take the place of natural affection, if reason and judgment are lost, and the mind becomes a prey to insane delusions calculated to interfere with and disturb its functions and to lead to testamentary disposition due only to baneful influences, in such a case it is obvious that the testamentary power fails and that a will made under such circumstances ought not to stand."

The same rules in reference to hallucinations, partial insanity, and temporary insanity apply to wills as to contracts and need not to be repeated here. However, there is one phase of mental peculiarity that often is presented in contests over wills that rarely is presented in contests over contracts, namely, the eccentricity of the testator.

Many men of thoroughly sound mind have entertained various eccentric ideas and fancies. These eccentricities frequently relate to the future state of man and the occult in reference to life. The general rule is that mere eccentricity of the testator is not sufficient to overturn a will, especially where the eccentricity was not manifested in the will itself.

D. Marriage.—While marriage partakes largely of a religious and social relation, yet it is also a legal relation. So much is this true that an insane person cannot bind himself by taking marriage vows.

One of the ablest judges that ever adorned the Supreme Bench of Tennessee, Judge Robert L. Caruthers, speaking for the court, in the strange case of Jemima Coles, said: "The test question in all such cases is, whether the party is capable of making any binding contract. The identity of the doctrine that unsoundness of mind vitiates this as well as all other contracts is well established. But every consideration of policy and humanity admonishes us that a contract so essentially connected with the peace and happiness of individuals and families, and the well-being of society, should not be annulled on this or any other ground not clearly made out. The general rule is that those who have not the regular use of their understanding sufficient to deal with discretion in the common affairs of life, or the weakness being so considerable as to amount to derangement, are incapable of contracting a valid marriage."

In the case involved, which illustrates the opinion of the court, complainant, the wife, had been married before the marriage in controversy. At the time of the marriage in question she was about forty-six years of age. For a number of years prior to the marriage she suffered with *prolapsus uteri*. During this period she was afflicted with paroxysms and in these paroxysms was subject to delusions. These delusions were ungrounded apprehension of conspiracies against her life by her own slaves. They were attempting to kill her. She was wild and foolish when in those spells, and when not under them was very eccentric. She had great weakness for beaux before this marriage, and boasted of conquests and showed her many love letters. She became permanently insane in 1850, three years after the marriage in question.

The court held that as the marriage was not consummated while under the effects of a paroxysm, and as the proof showed that at other times, though eccentric, she managed her own business with judgment and understanding, the marriage was valid. *John Bell Keeble.*

CLAREMONDE CHALYBEATE SPRING.—Washington County, Georgia.

Post-Office.—Worthen.

Access.—Viâ Georgia Central Railroad to Tennile; thence by Sandersville and Tennile Railroad three miles to Sandersville; thence by private conveyance nine miles to Worthen. Following is a qualitative analysis of the water:

Iron carbonate.
Potassium carbonate.
Calcium carbonate.
Potassium sulphate.
Sodium chloride.
Alumina (trace).

The iron carbonate is present in the proportion of about four grains per gallon. The quantity of other ingredients is small. This is a very good chalybeate water, and will no doubt be found beneficial in all diseases in which the carbonated iron waters are indicated. The spring is pleasantly located in a private park.

James K. Crook.

CLARENDON SPRINGS.—Rutland County, Vermont.

Post-Office.—Clarendon Springs. Hotel and cottages.

Access.—Viâ Delaware and Hudson Railroad to West Rutland Station; thence four miles to springs. This point is seven hours by rail from New York, five hours from Boston, three hours from Troy and Albany, and two hours from Saratoga.

The springs are four in number, and are located in a beautiful valley among the green hills at a level of one thousand feet above the sea. This is doubtless one of the oldest resorts in the country, the medicinal character of the water having been discovered by one Asa Smith, it is said, in the year 1776. From fifteen hundred to twenty-five hundred persons visit the springs annually in pursuit of health and pleasure. Amid the beautiful scenery, pleasant drives, and rare opportunities for trout fishing, the visitor may while away the summer days in a delightful manner. The hotels are said to be of an excellent character. The following analysis was made by Professor Hayes, State Assayer of Massachusetts:

One United States Gallon Contains:

Solids.	Grains.
Calcium carbonate	3.02
Calcium chloride Sodium sulphate Magnesium sulphate	2.74
Total	5.76
Gases.	Cu. in.
Carbonic acid	46.16
Nitrogen	9.36

The analysis is evidently incomplete, and a re-examination is desirable. The water is a very pure and wholesome beverage, independently of its medicinal qualities. It is used commercially. *James K. Crook.*

CLARK'S RED CROSS MINERAL WELL.—Mecosta County, Michigan.

Post-Office.—Big Rapids.

This water was discovered on the farm of A. L. Clark, adjoining the southern limits of the town of Big Rapids, in June, 1890. The workmen were boring for gas, but at the depth of thirteen hundred feet they struck a vein of water which escaped under such a heavy pressure that the drill, weighing nearly twenty-five hundred pounds, was borne up with it. The water was submitted to Prof. Albert B. Prescott, of the University of Michigan, who found the following list of mineral ingredients:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	13,048.59
Magnesium chloride	1,390.78
Calcium chloride	3,261.18
Sodium bromide	86.95
Calcium sulphate	33.24
Iron carbonate	4.46
Silicic acid	.07
Aluminum	Traces.
Potassium	Traces.
Total	17,825.27

Specific gravity at 62° F. (16.6° C.), 1.205.
Weight of one United States gallon of the water, 70,273.19 grains.
Reaction, neutral before and after boiling. Filters clear and colorless.

The analysis shows this to be one of the most heavily mineralized waters known. A bath-house for the local use of the water has been erected on Maple Street, opposite the Northern Hotel, and the water is also used commercially. For internal use it is recommended in very small doses, from one-half to two teaspoonfuls four times a day, diluted with plain water. It is said to act as an emetic or as a purge if taken too strong.

The water is recommended for numerous internal disorders, and also for its local effects in ulcers, cuts, burns, or bruises; as a lotion in conjunctivitis, as a gargle in pharyngitis, as an injection in leucorrhœa, gonorrhœa, etc. The hot baths are stated to be of decided value in old cases of obstinate rheumatism. The water is odorless, and it is said that it never freezes at any temperature known in Michigan. *James K. Crook.*

CLARK'S RIVERSIDE MINERAL SPRINGS.—Wayne County, Michigan.

Post-Office.—Detroit.

This resort is located on Fort West Street, corner of Clark Avenue, about two miles from the centre of the city of Detroit. It is reached by electric cars, which pass the door of the bath-house every five minutes. This bathing establishment, which was recently opened to the public, is one of the most elegant and luxurious to be found in the country. The springs are two in number, and furnish an abundant flow of water. An analysis by Samuel P. Duffield, M.D., Ph.D., made in November, 1889, resulted as follows:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	3,408.50
Potassium chloride	.18
Calcium chloride	860.00
Calcium sulphate	1,790.98
Magnesium sulphate	1,082.02
Magnesium carbonate	11.22
Calcium carbonate	149.16
Silica	3.50
Alumina	13.41
Total	7,318.97

Sulphureted hydrogen gas, 40.76 cubic inches.
Temperature of water, 56° F.

The bath-house is kept open all the year. The waters have been found very useful in the diseases to which the saline-calcic class is applicable. *James K. Crook.*

CLASTOTHRIX. See *Atrophia Pilorum Propria.*

CLAVICLE. See *Shoulder.*

CLAVICLE, SURGERY OF THE.—The clavicle may be congenitally absent or partially defective. It may be deformed in rickets and osteomalacia, or as a consequence of badly united fracture. Fracture of this bone may occur *in utero.*

Diseases of the clavicle are rare. The principal ones noted are syphilis (gumma), tuberculosis, and osteomyelitis; with resulting periostitis, osteitis, abscess, caries, or necrosis.

Neoplasms of the clavicle are seldom met with. The variety of new growth most often seen is some variety of sarcoma. Carcinoma is much more rare and its occurrence as a primary growth appears somewhat doubtful.

Osteomata (exostoses) and enchondromata are seldom reported.

Traumatism may cause contusions, wounds, fractures, or dislocations. Wounds and contusions require no special mention. (See special articles on *Fractures* and *Dislocations.*)

The diseases and neoplasms of the clavicle present no clinical features peculiar to this bone. In syphilis, *treatment* with mercury and iodide of potassium should be thorough, and if portions of bone die they should be removed. Tuberculosis is apt to begin here in the periosteum, and the sharp spoon should be employed to remove the foci as thoroughly as possible, especially if suppuration threatens or actually takes place. When suppurative osteomyelitis is recognized, an incision should be made over the affected area, and after raising the periosteum the affected portion of bone should be chiselled or scooped away and the resulting cavity drained. Abscess, as elsewhere, requires incision and drainage and the removal of any dead bone.

Compound fractures, particularly if caused by pistol or rifle balls, require a thorough examination and disinfection under an anæsthetic. One may decide also to keep the fragments in apposition by sutures, or to excise the whole or a part of the clavicle. The question of suturing simple fractures of the clavicle is still unsettled. When there is marked deformity, and particularly when sharp fragments appear likely to cause damage to important vessels or nerves in their neighborhood, the operation has some warm advocates.

The principal *operative procedures* on the clavicle are *suturing,* or wiring for fracture or dislocation; *curetting,* for tuberculous or syphilitic foci; *incision,* chiselling, etc., for osteomyelitis or removal of necrotic fragments; *excision* of the clavicle, partial or total; and temporary *resection.* The formation of a *clavicular pseudarthrosis,* for the relief of ankylosis of the scapulo-humeral articulation, has been suggested by Tillaux.

Excision of the clavicle, whether partial or total, may be done beneath the periosteum or outside it. Nearly half the cases of total extirpation of the clavicle collected by Norkus were for "necrosis" or "caries." When operating for these diseases, for fractures, or for benign new growths, the subperiosteal method should be employed. Where it has been made use of, restoration of the bone has taken place to a considerable extent or has been complete in the majority of cases, and the functional result was excellent or perfect, while in some there was no apparent deformity. An incision is made from one end of the clavicle to the other, extending through the periosteum, which is then detached from the bone with an elevator. The clavicle is then disarticulated at either extremity first, as may be most convenient; or it is divided at some intermediate portion and the two extremities are separately released from their attachments and removed. Care is to be exercised not to injure the large vessels adjacent to the sterno-clavicular articulation. It may be necessary to prolong the incision beyond either joint, or to make smaller transverse incisions at either extremity of the wound in order to gain better access to the articulations. When the disease process has separated the bone from the periosteum, it may be possible to extract it through a fistulous tract, or through a small incision dividing the skin and periosteum at a suitable point. Partial excision of the clavicle, removing more or less of the outer or inner extremity or a portion of the middle of the clavicle, may be performed for partial affections of the clavicle in non-malignant diseases. For sarcoma and other malignant new growths, neither the partial nor the subperiosteal method should be resorted to. In the thirty-two cases of extirpation of the clavicle for tumors (sarcomata in twenty-four instances) collected by Norkus, six deaths from the operation resulted. The incision is the same as in the subperiosteal operation. The cutting must always be done toward the periosteum, the attachments of the muscles should be carefully severed from it, and the bone should be removed either in fragments after cutting or sawing through it, or as a whole, including the new growth. The wound is to be closed by suture after the divided sterno-cleido-mastoid and trapezius above have been carefully united by deep sutures to the pectoralis major and deltoid muscles below.

Madelung advocates *temporary resection of the clavicle* to give access to the subclavicular region. He recommends the division of the clavicle in its inner third, together with the subclavian and both pectoral muscles, in order to separate widely the divided ends of the clavicle. This gives free access to the subclavicular space and even to the axilla. The clavicle is divided obliquely from above and within downward and outward, in order that the subsequent adaptation of the parts, when the wound is closed, may be more perfectly secured. The pull of the sterno-cleido-mastoid muscle and the weight of the arm are better opposed by the adoption of this plan than if we resort to the straight backward division of the clavicle.

The operation is proposed for the purposes of gaining access to the subclavicular nerves and blood-vessels, of extirpating subclavicular and axillary neoplasms, of attacking diseases of the upper ribs, and of reaching the apices of the pleuræ or lungs.

William G. Le Boutillier.

REFERENCES.

Norkus: Beiträge zur klin. Chir., xi., 728.
Madelung: Beiträge zur klin. Chir., xiv., 229.

CLAVUS. See *Callositas.*

CLEAR CREEK SPRINGS.—Bell County, Kentucky.

Post-Office.—Pineville. Small hotel.

Access.—Viâ Cumberland River and Tennessee Railroad, which connects with the Louisville and Nashville Railroad at Pineville, a distance of three miles from the springs.

The location of the springs is in the Clear Creek valley, almost entirely surrounded by mountains. The elevation is about thirteen hundred feet above the sea level. This region possesses many advantages in the way of charming scenery, exhilarating mountain air, etc. The springs in use are two in number, possessing about the same general characteristics. The following analysis was made by Robert Peter, State Geologist of Kentucky, in 1883:

One United States Gallon Contains:

Solids.	Grains.
Calcium carbonate	2.07
Magnesium carbonate	Traces.
Calcium sulphate	.33
Magnesium sulphate	1.43
Calcium chloride	.16
Sodium carbonate	1.84
Silica	.51
Alumina	Traces.
Total	6.34

The water is said to be remarkably pure and well adapted to the uses of the table. We are informed that it has long enjoyed a considerable reputation in dyspepsia, liver and kidney affections, skin diseases and disorders of the female pelvic organs. *James K. Crook.*

CLEAVERS. See *Rubiaceæ.*

CLEFT PALATE.—By cleft of the hard and soft palates we mean a fissure of greater or lesser degree existing in the roof of the mouth, including, it may be, the alveolar ridge in front, and extending back to the extreme end of the uvula. These clefts are of two kinds, congenital and acquired, the former being by far the more frequent.

Pathology.—As to the congenital form, nature does not complete her work as originally intended, and while we can consistently indorse the views of those who think the defect to be entirely due to the want of a meat diet and of sufficient phosphates of lime on the part of the mother, still there are many other factors to be considered.

H. E. Dennett, D.D.S., of Boston, has stated that "all flesh-eating animals take as much of the bone with the flesh they eat as they can break with their teeth sufficiently fine to swallow, and all have good dental organs."

Several years ago the lions in the Zoölogical Gardens of London were fed upon flesh containing too large bones for them to break and swallow. The young born while this method of feeding was pursued, it was observed, had cleft palates and lived but a short time. The lions were then fed upon small animals, whose bones they could break easily, and the young born afterward had perfectly formed palates.

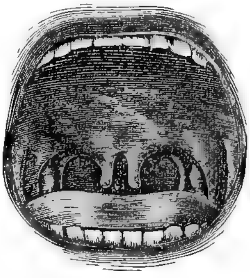

Fig. 1361.

It is safe to assert that the same causes which produce rickets in children have also a like effect in producing cleft of the hard palate. Hereditary tendency has been mentioned by some authors, and this I have observed in the history of some of my own cases.

Mr. Lawson Tait, F.R.C.S., in his paper on "Cleft Palate,"[1] has very briefly, in somewhat different words, referred to this pathological condition, and is very strong in his belief that in certain localities it is quite endemic, and that, in his experience, heredity had been a great factor. He says he has known cleft to miss as many as three generations, and then appear in an hereditary form.

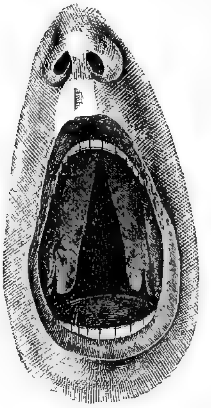

Fig. 1362.

The late Dr. Gurdon Buck has reported a number of interesting cases of hereditary cleft occurring in his practice, upon which he operated with success.

I lay much stress upon asking the parents questions bearing upon these points.

Intermarrying is an element to be considered in the study of the pathology of these cases (see Fergusson's "Surgery").

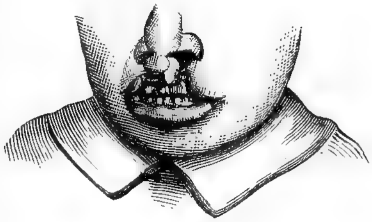

Fig. 1363.

In a majority of cases in which the fissure is single, it is to be found on the left side, and the deviation of the two segments of the alveolar circle is fortunately, in these cases of single split, seldom great. My experience has been that in double fissure through the alveolar ridge, the vomer often has its only support below in the intermaxillary projection, that is, the intermaxillary bone or bones appear as an appendage to the vomer, being held or assisted in position by fibrous, cartilaginous, and mucous tissues. This island of intermaxillary bones and tissues, which is so very noticeable in double harelip, especially when associated with double split or fissure of the alveolar circle, has been a source of deep study to histologists as well as to pathologists. The former have spoken of it as analogous to the premaxillary bones in some of the lower animals, and yet it has been very difficult to detect, in the youngest fœtal human upper jaw, the difference between the intermaxillary portions and the lateral or true portions of this bone. However, we know that this so-called island does contain what may be termed the true intermaxillary bones and the temporary and permanent incisors, in cases of complete double cleft having only the middle ones perfect, the lateral incisors often being imperfect or entirely absent. This condition of the incisors I have observed in cases in which it became necessary to remove the island. Such instances of removal are fortunately rare.

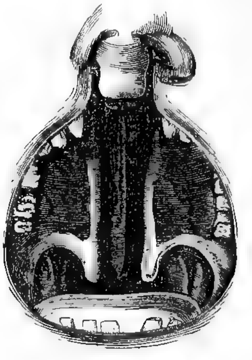
FIG. 1364.

Singular as it may seem, Fergusson states that this line of separation, just spoken of, cannot always be traced in the well-developed fœtal skull; yet the suture remains quite distinct in the palatine portion of this bone until a late period of adult life.

The surgeon is obliged to take somewhat into consideration the structure of this island or the intermaxillary substance, in determining the line of treatment to adopt.

Cleft of the hard palate, as well as harelip directly through the mesial line of the intermaxillary bones and soft parts, is very rare.

Tait says two specimens are known. I have seen one case of median harelip. Sir William Fergusson states that he has never seen a case.

Maternal impressions are often suggested as a cause of this deformity. We can give but a very slight indorsement to this view of the question.

Congenital cleft of the hard and soft palates may be exceedingly simple, only the uvula, as seen in Fig. 1363,* being implicated, or it may, in different degrees, be confined to the soft palate, or it may extend forward to, or into, the alveolar ridge (Figs. 1362 and 1363), or finally, it may double-fissure the alveolar circle (Fig. 1364).*

The fissure is oftener situated in the roof of the mouth, so that the vomer is to be seen in the middle of the split (Fig. 1364).*

At times the vomer is fastened to one or the other side (Fig. 1365),* generally to the left, and this location of it is always a source of embarrassment in operating. It is here that a combination of the Fergusson bone operation and the Warren operation—the former on the side free from the septum, and the latter on the opposite side, sliding the periosteal flaps—meets the emergency best. To break the vomer, as I did in some of my earlier cases, is not always a success, and we are more likely to get necrosis, especially of the septum.

It is well known that many infants born with this defect die within a short time after birth, when the cleft is of a marked character. Mr. Tait says that one-half of the children born with extensive clefts die within a few days after birth from starvation, and thinks we might be able to save many of these children if we could help them to suck by early giving them a roof to the mouth, and therefore advocates doing the operation for closing the hard palate as early as the third week. My personal experience does not show so high a rate of mortality. When speaking of treatment, I shall refer to this again.

Children born with cleft palate cannot nurse, nor can they, in many instances, use the large rubber nipple of the nursing bottle with complete success. Mason, in his excellent work, mentions the large flat nipple, made so as to fill the roof of the mouth while nursing, as of great use.

When the children must be fed with a spoon, a great care devolves upon the mother or nurse. Among my cases I have the notes of two (a son and a daughter in one family) in which the mother, for nearly two years in each instance, was obliged to give nearly her entire time to the care of the two children, as regards feeding, before they could help themselves. In neither of these cases was an early operation done for closing the double harelip. (Fig. 1363 shows condition of the son.)

Cases allowed to go on without interference beyond the second year are those that show the loss of voice and the nasal tone in so marked a degree. This often proves a source of great annoyance in after-life, keeping the possessor from society and from following a professional career. It is interesting, as we study the history of this subject, to note the views of different surgeons who have published their cases, as to the proper time for operation, especially in reference to the recovery of the voice.

I have now performed the operation so many times, in patients of from twenty months to nineteen years of age, that I am entitled to speak from experience, and am convinced that our most successful cases are those upon which we operate early, and before the child has made any great effort to speak. In fact, these cases should not be encouraged to talk early. Most children make an earnest effort to talk at the end of the second year, and by that time the operation should have been performed. From my own observations of the results obtained by other surgeons who have closed the cleft as early as the second or third month of infant life, and from my study of the literature of the subject, as well as from my personal experience, I am not in favor of going so far as this in the direction of early operating. Young children do not bear the loss of blood well, and although we may make use of the galvano-cautery knife to divide the tissues and thus avoid hemorrhage, yet the shock is such as to add to our mortality list, and, besides, union often fails in these early attempts. Of this, however, I am certain, that in all these cases of cleft palate complicated with single or double harelip, the operation upon the soft external parts should be done as soon after birth as possible. With the large nipple and perfect lips to surround it, or simply by the use of the spoon, the child can be fed very well. The union of the soft parts does aid, I am convinced, in bringing together the bony vault of the mouth, a result which is very desirable. Then again, it does to a certain extent carry the child out from the domain of idle curiosity and observation, and thereby lessens the burden of the parents. Some of these children will die before reaching the age of two years, not because of imperfect mastication, but because they are bound to bear their ratio of death with the rest of the infant family.

In double harelip, while the treatment of the island or intermaxillary bone has been dwelt upon very clearly by the various writers, I am sure that of all the different complications, it is in this that experience is of the greatest value, and that every case presents one or more peculiar features. To save the island when possible is, I think, good surgery. There can be no doubt that it prevents the child-like contraction or appearance which is so striking in some adult faces where it has been removed. I think the cases are few in which, in saving the island, the operator can go on and unite both sides in the same operation.

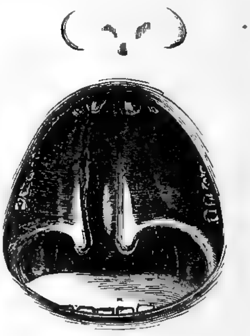
FIG. 1365.

As to the manner of closing the single harelip, there can be little difference of opinion. The law is inflexible that to produce a good result the vermilion border of the lip must be always on a line projecting a little, if possible. If not, an apparent notching occurs in the vermilion border.

Regarding the mode of dealing with the island, my preference is, if I cannot save the bone, to save the healthy skin covering it, be it ever so small, and to shape it in such a way that by angle, curve, or square I can fit it either into, between, or to one side of the upper lip, using that to form flaps. The small portion thus saved aids in its way to give an appearance of fulness to the face or upper lip. In one of my cases, sent me by Professor Bigelow, of Albany, there existed that dreadful deformity, such as is seen in a small number of cases only, in which the island projected upward almost like a horn toward the nose. There was quite a surface of healthy skin covering it, and I determined to save it all. Accordingly, I first took from the septum, with curved bone forceps, a V-shaped portion of bone, and then broke the island into position on a level with the alveolar ridge of the upper jaw, holding it there for a period of ten days with compress and adhesive plaster. Two weeks later I freshened the edge of the fissure on the left side, also the edge of the skin covering the island, and then brought the flap or upper lip up to it, holding it there with two silver pins. Good union was obtained (see Fig. 1366). Two months later—the child being then not quite six months old—I treated the fissure on the right side in a similar manner, and got a perfect result. Unfortunately for the completion of the operation for closure of cleft of the hard palate, this child died of cholera infantum just at the end of its second year, and at a time when the parents were ready and anxious for the final operation.

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* From Mason, "On Harelip and Cleft Palate."

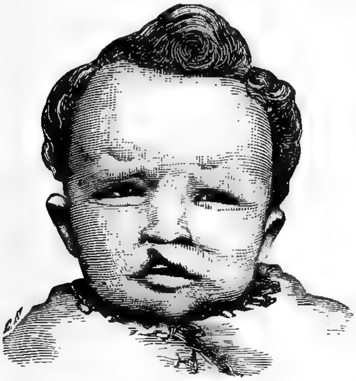

FIG. 1366.

The saving of the island gives a better septum for the nose, as is reasonable to conclude from a comparison of this case with another in which the island was removed. In the latter case, a boy six months old, there was a double harelip with the intermaxillary bone so prominent that it was deemed best to remove it entirely. At the first operation, when this was done, a lateral incision was made from the angle of the nose on each side outward into the cheek, and then the two flaps forming the upper lip were brought together; perfect union was thus secured. Later on, and in his second year, two operations were required for closing the cleft in the hard and soft palates; but his voice did not improve as I had hoped. I did not see him for nearly three years, when he was brought to me, and on examination I found that the upper lip had no union with the septum or vomer, and that through this opening the air escaped in so great a volume as partially to account for his defective speech. These cases are difficult to remedy.

In the case of a boy who was four years of age, and whose face was almost as much disfigured as was that of the case just narrated, I operated the same number of times, but I did not remove the intermaxillary bone. The result obtained, as to appearance and voice, was nearly perfect.

Just here I wish to speak of the necessity of operating upon the soft parts in such a manner as not to leave any scar behind. On this point Mr. Lawson Tait says: "To avoid these scars I use ordinary seamstresses' needles, strong, and threaded with a few inches of silver wire double. I introduce each needle through the lip (in the plane of its surfaces), about half an inch from the prolabium, and bring the point out at the middle of the cut surface. I then introduce the needle at the corresponding point of the opposite cut surface, and bring it out at the root of the ala of the nose. Thus, when both needles are *in situ* they form a St. Andrew's cross, the point of intersection being the centre of the wound. The needles are then pushed home up to their eyes, the wires twisted firmly together, the points cut off close to the skin, and the stumps retracted into it. Thus all possible scarring is avoided."

In my article on *Harelip* I shall speak more fully on this subject, having little reason to regret the use of the ordinary silver harelip pins.

In these operations I do not hesitate to make use of chloroform, and especially in children under ten years of age. Before it is given everything should be in readiness, and each assistant should be instructed as to his work; then, as the little one comes under the influence of the anæsthetic, the operation should be begun with promptness. It is true, many of these children are of feeble make-up, but the cases are few in which one need feel at all anxious in giving the chloroform from a small plain napkin, plenty of air being allowed.

The subject of cleft of the hard and soft palates is one not so well settled in the minds of surgeons as to exclude further elucidation, and, while it is hardly safe for one to attempt to advance much that is new, I am convinced that a more careful examination of our cases, and of the reports of the same, one, two, or more years after an operation has been performed, is needed. It will ever remain a source of regret to the profession that such successful operators as Warren and Fergusson (the latter operating over three hundred times) did not leave a record as to how the operation ultimately affected the voice, the restoration of which is the principal object sought for in doing so difficult an operation.

That it is a severe operation there can be no doubt, especially when the attempt is made to close a complete cleft. In my own practice, furthermore, I have experienced repeated failures in a few cases. Nevertheless, in these very cases, with one or two exceptions, I have finally conquered, and in none was the patient left any the worse for the future trial of an obturator. That cases do get on in life without any operation being done, and are then improved by the use of an obturator, is now a well-established fact. However, these cases are not always so bene-

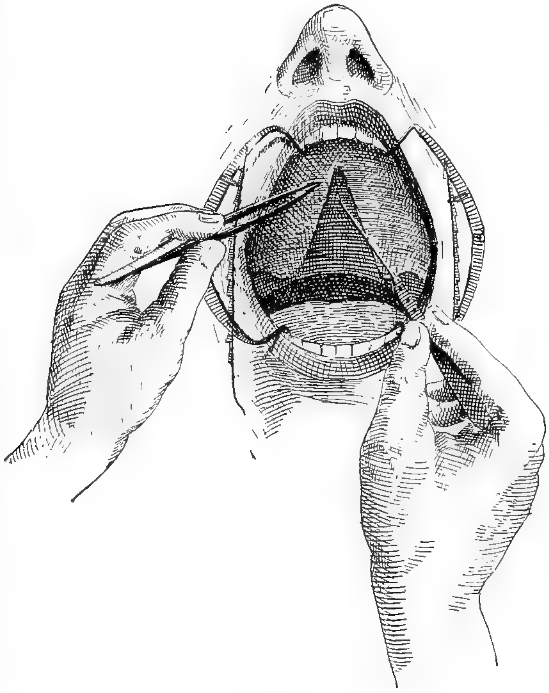

FIG. 1367.

fited. A gentleman with whom I am acquainted, aged seventy, was operated upon when a child for harelip, by Guthrie, and then given to the dentists for relief when eighteen years of age. He has never been in the least improved by the use of obturators, and life has ever been to him a sorrow. It is with great difficulty that he can be understood.

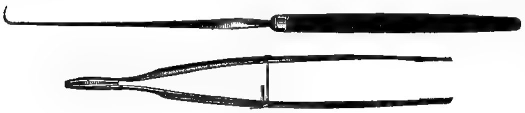
FIG. 1368.

I have never yet been obliged to stop an operation because of hemorrhage, but I have known it to occur at times in a severe manner. Once I was compelled to postpone an operation on account of the great and rapid secretion of mucus, it being so abundant that the bronchi filled to an alarming extent, and suffocation seemed imminent. When the second attempt was made I put the patient for twenty-four hours upon full doses of tincture of belladonna, which had the desired effect of drying the throat and checking the free secretion of mucus.

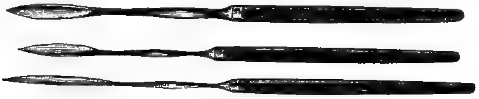
FIG. 1369.

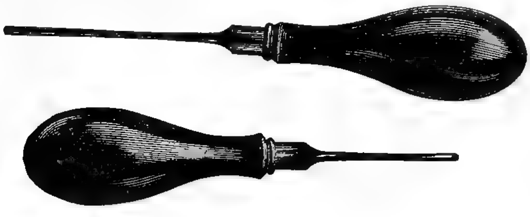
FIG. 1370.

The subject of cleft palate is one that has occupied the minds of our best surgeons both in this country and in the old world, and each can claim a good degree of success. It is not necessary at this point to enter into the details of the history of the operation. It is enough to know that Billroth, Lawson Tait, Francis Mason, T. Smith, Goodwillie, Prince, and many others of our own time, have given the matter careful consideration. It is an operation in which experience is of service as to dexterity, as to time consumed in doing it, as to teaching the mother or the nurse how to improve the speech afterward, and also, I believe, as to the choice of the proper time for operating. I think that, if we could get honest statistics, we should find the best time for operating to be immediately after the first dentition, or when the child is about two years old, and that previous to this no attempt should be made to encourage the child to talk. Then there is not so much danger of acquiring that nasal twang which is so difficult for an older person to overcome. The rule stated above should also apply to cases of incomplete cleft, in which there is no harelip.

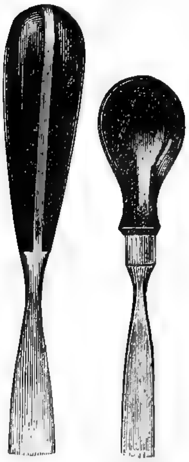
FIG. 1371.

The acquired form of cleft is the result of a variety of diseases and accidents. Of the former the most frequent is constitutional syphilis in the adult. In children it is usually the result of a fall while running with something in the mouth, as a bean-blower, pencil, or pen, the force being such as to drive the article through some part of the roof of the mouth. These forms of fissure are situated strictly behind the alveolar ridge, and, as a usual thing, are not large. They will be considered more fully when speaking of treatment.

Staphylorraphy is an operation suited especially for closing a cleft of the soft palate, also such as are associated with but slight fissures of the hard palate.

Osteoplasty is essentially the bone or Fergusson operation. I have combined the two in closing a complete cleft of both hard and soft palates, and have had no reason to regret it, although it is a severe operation.

STEPS OF THE OPERATION.—The child's bowels having been moved the day before, no solid food should be given on the morning of the operation. I was once greatly embarrassed in a case in which the nurse had given the child a large plateful of oatmeal gruel, which it continued to vomit during the entire operation.

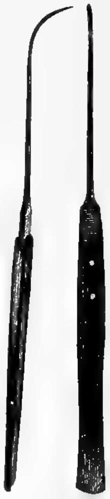
FIG. 1372.

Chloroform may be given, and when the anæsthetic takes effect the Whitehead gag, which I consider the best, should be introduced as shown in Fig. 1367. The operator should have ready a good supply of bits of sterilized gauze (not too large) with at least a dozen good sponge holders, long enough to reach well back into the pharynx. It is necessary, too, to have near at hand a bowl of cracked ice, in which to dip the bits of gauze intended for use in controlling hemorrhage. The surgeon requires as his assistants, one to give and watch faithfully the anæsthetic, another to sponge, a third to hand the instruments and assist generally, and two others to look after the mops of gauze.

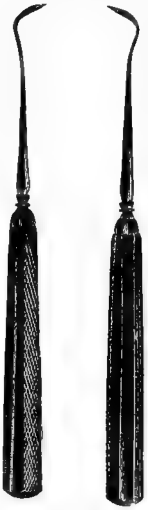
FIG. 1373.

The operation should be performed in front of a good light, and the patient's head should rest on a firm pillow. Some operators speak very favorably of letting the child's head hang over the table, the blood being sponged out as it collects in the posterior part of the pharynx.

The essential steps of the operation are as follows:

First. Standing on the right side of the patient with forceps or tenaculum (Fig. 1368), the operator grasps the lower end of the uvula, on the left side, and, with long, sharp-pointed, narrow knife (Fig. 1369), freshens well the edges of the fissure, not hesitating to take away plenty of tissue, and frequently doing it without removing the instruments; in which matter, of course, much will depend upon the bleeding, and how well the child is under the influence of the anæsthetic.

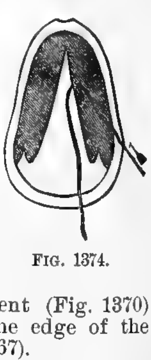
FIG. 1374.

Second. With an awl-shaped instrument (Fig. 1370) holes are bored through the bone near the edge of the cleft, for passing the sutures (see Fig. 1367).

Third. Similar holes, two on each side, are drilled through the bone along the alveolar ridge, sufficiently in front and not so far back as to interfere with the important blood-vessels, and then, by means of the chisel (Fig.

1371), the parallel portion of bone is pressed, or rather forced, toward the median line for the purpose of closing the cleft in the hard palate with bone and periosteal substance.

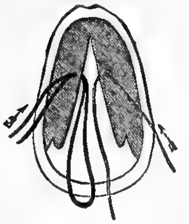

FIG. 1375.

Fourth. The blue and red silk threads forming the sutures are then passed alternately in the following manner, as shown in part in the accompanying illustrations: A blue thread is first passed through the anterior hole previously made in the left side of the cleft, by means of the long curved needle (Figs. 1372 and 1373), and the free end is drawn out by means of the long forceps; next, a red thread, doubled over so as to form a loop, is passed in the same manner through the hole opposite in the right side of the cleft, the loop being drawn through, and in this is engaged the free end of the blue suture in order to draw it through the hole on the right side, thus completing its passage, as seen in Figs. 1374, 1375, 1376, and 1377. In this way as many sutures as are needed are passed, the red and blue alternating.

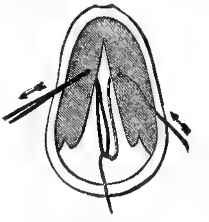

FIG. 1376.

Fifth. Tying the sutures is next done by means of the slip-knot. A half-knot is thrown around the free end of the suture (Fig. 1377), and then by the use of the fingers or instrument (Fig. 1378,) the knot is pressed tightly down against the edges of the cleft—which are thus brought together—and tied twice, as shown in the drawing taken from life (Fig. 1379), the suture being drawn to one side of the fissure and cut short with curved scissors.

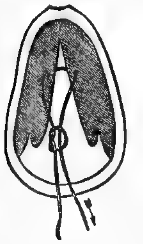

FIG. 1377.

This closes the entire split completely in one operation.

Sixth. This is a very important step in many operations. It consists in dividing the tissues at the point where the greatest tension exists. In examining my patients I was impressed early with the observation that, when they attempted to swallow and when they breathed with the mouth open, the two sides of the fissured soft palate very nearly, if not quite, came into apposition, except just opposite the hamular process and at the junction of the hard and soft palates; and, at the same time, there was thrown up on the posterior wall of the pharynx a transverse ridge formed by the superior constrictor, the latter aiding to prevent the passage of air or food up into the posterior nares. This observation led me to make the lateral incisions in the soft palate only at the point of greatest tension, and, that being the tendon of the tensor palati, to buttonhole it, as we may say, with a short blunt knife (Fig. 1380, after Fergusson). The relief afforded by this procedure is at once marked, but at times the hemorrhage is decided, and, therefore, I believe that the platinum knife of the galvano-cautery is the best instrument to use, and probably better than the wire suggested by Dr. David Prince, for this part of the operation.

This is essentially the same procedure as that of dividing what Mr. Lawson Tait so ably describes in his paper as the circumflex fascia belonging to the tendinous insertion of the tensor palati muscle, a failure to divide which so often causes non-union of the hard and soft palates.

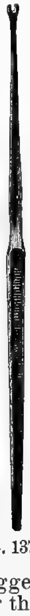

FIG. 1378.

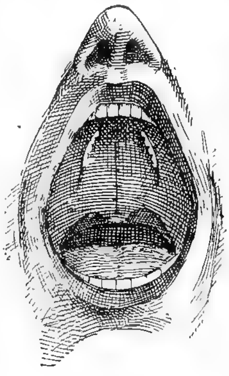

FIG. 1379.

Dr. David Prince, in a paper on "Palatoplasty," very clearly and ably discusses this subject.

Fig. 1379 shows the appearance of the mouth when the combined operations have been performed; the lateral alveolar incision having been well packed with strips of iodoform gauze. This step I consider essential, as it prevents the too quick union of this free incision, which is apt sometimes to occur. It is well to repack the incision on the third, fourth, fifth, or sixth day, the judgment of the operator determining the exact time.

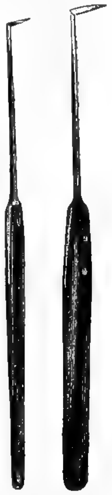

FIG. 1380.

When simple staphylorraphy is to be performed, the steps are much the same; the use of the awl and chisel in bringing the edges of the bone together should, however, be omitted, and where the hard palate is implicated the Warren-Langenbeck periosteal operation of sliding the covering of the bone as needed, should be performed. This is done by first making an incision through the mucous membrane and periosteum with a blunt-edged instrument or cautery knife; then, with periosteal elevators (Fig. 1381) the tissues should be lifted from the bone and toward the mesian line, the point of the instrument being carried posteriorly near to the posterior palatine arteries. This procedure, as Mr. Tait has observed, raises the vessels from their bed without injuring them. The point of the raspatory must not be introduced into the canal containing these vessels. Mr. Tait believes that if the muco-periosteum of the hard palate be elevated with a raspatory from the semilune of the palate bone, the tendinous attachment of the tensor palati will be raised with it, and the muscle will thus be paralyzed, thereby doing away with the necessity of any such division of muscles as is practised by Pollock or Fergusson, and diminishing the risk of there being a pinhole orifice at the junction of the hard and soft palates. After this, if tension of the soft palate be present, divide as before spoken of.

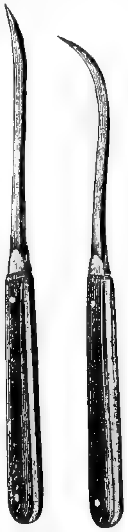

FIG. 1381.

The length of time during which the sutures should be left in is of importance. Tait leaves them in fourteen days and uses silver wire. Prince uses silver wire. Mason uses silk, and in many instances lets them ulcerate out. Other surgeons have suggested and used horsehair. I always use silk and remove some stitches as early as the sixth day and the remainder by the tenth. Colored silk is best. In removing the sutures it is well to put the patient under the influence of chloroform. Use long forceps and sharp-pointed curved scissors (Fig. 1382).

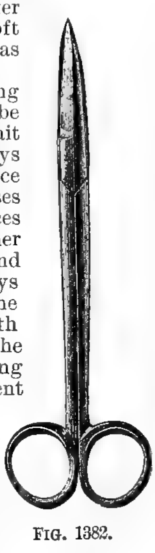

FIG. 1382.

A word as to the incision of the posterior pillar of the fauces as mentioned by Mr. Bryant. I have observed that there is a great difference between different individuals as regards the breadth of the space between the anterior and posterior pillars of the fauces, and where the soft parts are found to be very tense the posterior pillar may be divided; but we are warned by Mr. Tait that atrophy of the soft palate is likely to follow this operation, an outcome which is to be regretted. This condition I have noticed in one of my own cases.

Many cases require two and three operations, but we should not be discouraged. Contrast a good result with the frequent necessity of changing the obturator and the care required in looking after it.

Fig. 1383 shows the little pinhole opening (in some cases larger), which may often be closed by the persistent use of some caustic, such as nitrate of silver or nitric acid.

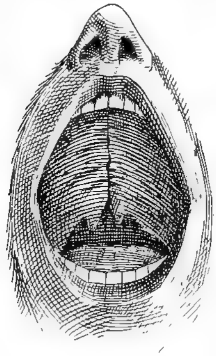

FIG. 1383.

Training the voice after the operation is of great importance as regards the final result. Great patience is required, and we must not expect improvement to follow immediately. A year, or even a longer time, may be required. With children I have had greater trouble in teaching the pronunciation of ch, as in church, chicken, etc., than that of any other sound. Dr. Henry J. Bigelow, of Boston, has in a very able manner presented the following views as to teaching the children to talk after the operation has been performed. He says: "Some years since I devised a short series of exercises for a patient I had operated upon. It begins with the only consonant which a patient can usually best articulate, namely, 't' in '*tar*,' and gradually leads to the rest, constantly referred to the acquired '*t*' as a point of departure. The great difficulty in pronouncing correctly with a cleft palate is in distinguishing the nasals from the mutes; thus, p and b from m; pab or bab from mam; t and d from n; tat from nan; k and g (hard) from ng. '*Tar*' is well pronounced by most beginners with an obturator. When the beginner can pronounce 'stark' and 'car' he has the key to most of what here follows. The above words should be practised carefully; not 'start' and 'tar,' but 'stark' and 'car,' and should be spoken loudly, or, as the elocutionists say, 'exploded.'

1. tar artar kar arkgar kar
2. kar arkar arkgar kgar gar
3. kar arkar arkdar kdar dar
4. kar arkar arkpar kpar par
5. kar arkar arkbar kbar bar
6. kar arkar arklar klar lar
7. kar arkar arksar ksar sar

Practise all the above with the following vowels:
8. o as in coke.
Thus, instead of kar, akar, etc., ko-oko-oklo-klo-lo.
9. a (long) as in cake.
10. i as in kite.
11. e as in keep.
12. u as in suit.

13. kar arkar arngar arkar arngar kar ngar
14. tar artar arnar artar arnar tar nar
15. par arpar armar arpar armar par mar
bar mar
Practise reading loudly from a book: { dar mar
sar rar"[2]

In the case of children beyond twelve years of age, and particularly with adults, I would perform the operation for closing cleft palate, if for nothing more than to afford comfort in eating.

Regarding the treatment of the acquired form of cleft, I should, in all cases of traumatic origin, operate by forming the periosteal flaps. In cases in which constitutional syphilis is present, I should hesitate somewhat, believing that in the majority of these cases the obturator does best.

A. Vander Veer.

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[1] British and Foreign Medico-Chirurgical Review, July, 1870.
[2] From Boston Med. and Surg. Journal, February 7th, 1884.

CLEVELAND.—The second city of size and importance in Ohio, situated on the south shore of Lake Erie at the mouth of the Cuyahoga River. It is a large and handsome city of several hundred thousand inhabitants, and from the abundance of its shade trees is called the "Forest City." The climate is indicated by the accompanying table:

CLIMATE OF CLEVELAND, OHIO—LATITUDE, 41° 30′; LONGITUDE, 81° 42′. PERIOD OF OBSERVATIONS, THIRTEEN YEARS.

Data.	January.	July.	Year.
Temperature (Fahr.)—			
Average or normal	26.8°	71.9°	48.9°
Average daily range	13.7	14.9	
Mean of warmest	32.8	79	
Mean of coldest	19.1	64.1	
Highest or maximum	70	96	
Lowest or minimum	−17	49.6	
Humidity—			
Average relative	77.9%	70.1%	71.2%
Precipitation—			
Average in inches	2.50	4.21	38.40
Wind—			
Prevailing direction	S.W.	N.	S.E.
Average hourly velocity in miles	10.7	7.3	9.3
Weather—			
Average number clear days	2.8	9.6	83
Average number fair days	8.4	15.7	141.8
Average number fair and clear days	11.2	25.3	224.8

Edward O. Otis.

CLIFTON SPRINGS.—Ontario County, New York.

POST-OFFICE.—Clifton Springs. Hotel and sanitarium.

ACCESS.—Viâ Auburn branch of the New York Central and by the Lehigh Valley railroads.

This resort is located in one of the most healthful parts of the State, midway between the villages of Geneva and Canandaigua. The location is about six hundred and seventeen feet above the sea level, and the surrounding country is somewhat hilly. An average summer temperature of about 75° to 85° F. is the rule. The springs are very numerous, but only five are in use at present. Dr. Henry Foster, the superintendent, sends us the following analysis by the late Prof. J. R. Chilton:

SULPHUR SPRING.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	9.68
Magnesium carbonate	13.12
Sodium sulphate	7.76
Calcium sulphate	69.20
Magnesium sulphate	16.48
Sodium chloride	9.28
Calcium chloride	4.08
Magnesium chloride	4.08
Organic matter	Trace.
Total	133.68

Sulphureted hydrogen gas, present.
Carbonic acid gas, present.

This water is quite similar to that of the Greenbrier White Sulphur Springs of West Virginia. It is used to supply the Clifton Springs Sanitarium, the important feature of this resort. A staff of eight physicians (six gentlemen and two ladies) is maintained at the sanitarium and it is believed that the facilities for treating certain classes of diseases are unsurpassed anywhere. All varieties of baths are here to be found, as well as all the modern appliances and methods of using electricity. The use of massage, the Swedish movement, and the various forms of gymnastics also receive due attention. The sanitarium building, with its recently constructed annex, affords accommodation for four hundred and fifty persons. All modern contrivances for the comfort and health of the guests are provided—elevators, an electric bell service, a solarium, roof garden, etc. The surrounding park, containing more than fifty acres, beautified by well-kept lawns, spacious pavilions, attractive walks, miniature lakes, shady groves, flowers, etc., provides a healthful and restful retreat. The house is kept open for guests all the year, but the greater number visit the place during the summer months. *James K. Crook.*

CLIMATE.—The word climate comes from the Greek word *κλιμη*, an inclination or slope. It was applied anciently to signify the supposed horizontal obliquity of the surface of the earth from the equator to the pole. The earth was divided by the earlier astronomers and geographers into parallel climates, or zones, that differed successively from each other from the equator to the pole by some arbitrary increment in the length of the midsummer days. Indirectly these zones, or climates, marked out more or less accurately the gradual changes in the characteristics of the weather dependent upon decreasing insolation. In modern usage the word climate has reference to the weather of a place or region, and to the factors that cause the weather to differ in different regions. It is difficult to give a rigid definition of the modern acceptation of the word climate, because different meanings have been given to it by different writers, just as different conceptions of its scope or the intents and purposes of its users have dictated. As used subsequently in this article the word climate is applied to the totality of those physical conditions of the atmosphere of a place or region that recur with more or less uniformity with the recurrence of the natural periods of time. Or, in other words, climate is the totality of the weather of a place or region as experienced there in the course of a long period of consecutive years. Weather itself is the instantaneous condition of the atmosphere with respect to its physical state. In a more extended sense weather is the continuity of the successive variations in the physical conditions of the atmosphere. In this sense, it is common to speak of the weather at noon, sunset, or any other time of the day, or of the weather of the whole day, or of the month, or of the year, and even of several years in succession.

The investigation of the causes that produce the weather and of their laws and principles of operation constitutes the branch of science known as meteorology. The further study of these causes to find out and classify those that are operative in producing the more or less periodical recurrences of the weather constitutes what is known as climatology, or the science of climate. Climatology is dependent upon meteorology, and meteorology in turn derives benefit from the advancement of climatology. For descriptive purposes, climate is usually stated in terms that have reference or regard to the temperature of the air, its humidity, motion, density, transparency, and electrification; also to the amount of precipitation, that is, the quantity of rain, snow, hail, sleet, dew, and frost, that occurs, and to its distribution: these items are referred to as the climatic elements. The conditions that cause variations in the intensity of the climatic elements constitute the climatic factors; the principal ones of which are latitude, altitude, distribution of land and water, mountain ranges, ocean currents, prevailing winds, amount and distribution of rainfall, nature of the soil and its drainage and vegetation, and the slope of the surface. These factors may be classified as fixed or natural factors, and dependent or resultant factors. The fixed factors are altitude, latitude, distribution of land and water, mountain ranges and slope of the surface, and nature of the soil; the dependent or resultant factors are the ocean currents, the prevailing winds, precipitation, soil drainage, and vegetation. As different regions and places on the earth's surface differ with respect to one or more of these factors, the climates of such regions necessarily differ more or less from each other. To describe exactly the climates of the different regions of the earth would be a task too great to be undertaken, but fortunately such exactness is not necessary to a practical comprehension of the climatic possibilities of any given spot on the globe.

Certain important principles are learned from meteorology that go far toward enabling us to anticipate from the geographical position and natural features of a place relative to some other place, whose climate is known, what the climate of the former is likely to be. Primarily, climate results from the effects on the earth's surface of the incident solar energy and its unequal distribution, which follows of necessity from the shape of the earth and its motions and its inclination with respect to the ecliptic. Other disturbing causes are introduced by the heterogeneous nature of the earth's surface. All of these causes have been alluded to as the climatic elements and factors. Their actual operations and effects will become plainer if we first consider a hypothetic earth and sun. From the laws of general physics, we can predict with as much certainty as we can predict the future course of the earth in its orbit what would be the climatic conditions upon every part of our imaginary globe. Starting with a homogeneous, smooth spheroid, either land or water, having an atmosphere of the same composition as our actual atmosphere, situated with respect to its sun as the actual earth is to its sun, only having no axial revolution, the sun revolving round the earth instead, let us consider what kind of climate it would have. The amount of solar energy received on each and every meridian by our hypothetic earth would be distributed from the equator to the poles in a ratio that would vary approximately as the cosine of the latitude (this is also true with regard to the actual earth, and is an important fact to bear in mind): the temperature of its atmosphere would therefore decrease gradually poleward on each side of the equator and every place on the same parallel of latitude would have the same temperature.

As the temperature controls the amount of moisture in the atmosphere, places on the same parallels would have the same degree of atmospheric humidity. The same conditions of equality would be true, also, of the winds and their velocities. In short, the climate of a given spot would be determined by its latitude, and all places in the same latitude would have the same climate. The general circulation of the atmosphere would be simple. The warmer air of the equatorial zone would expand, rise to a higher vertical level, and flow off toward the cooler poleward regions. The air of these regions, under the difference of pressure that would result from the accumulation of the overflowing air from the equator, would flow equatorward. This polar air, however, arriving in the equatorial zone would itself be warmed, expanded, and would overflow in like manner; and so a circulation would be established with surface currents from the poles to the equator, and upper currents from the equator to the poles, the direction of both currents being along the meridians. This would be the general tendency of the circulation. The actual circulation would be somewhat more involved. From the form of the surface of the spheroid over which this circulation would take place, the poleward moving air would be banked up more or less in its course by the lateral diminution of the area over which it was moving. The principle of the conservation of areas enables us to locate this banking up of the poleward moving air in the regions of latitudes 30°. The result that would follow would be an increase in atmospheric pressure in these regions with surface outflows on each side, those on the equatorial sides toward the equator, as in the first hypothetic instance; those on the polar side toward the pole, and opposite and antagonistic to the flow in the first suppositious instance. The result of this opposite poleward flow would be to overcome for a considerable distance the surface currents from the poles; the latter would be lifted from the surface and become middle currents. This underrunning and lifting of the polar currents would obtain to about the polar circles. The final result would be surface winds on the equatorial sides of latitude 30° toward the equator, and on the polar sides toward the poles; surface winds within the polar circles toward the equator; regions of variable winds and calms at the equator, latitudes 30°, and the polar circles. The circulation, however, would still be along the meridians.

If, now, our hypothetic earth and sun assume relations to each other like those of the actual earth and sun, a decided modification of this imaginary atmospheric circulation would take place. From the axial rotation of the earth, there would arise a right-handed deflecting force in the northern hemisphere and a left-handed deflecting force in the southern hemisphere. In the northern hemisphere, north winds would be deflected to the right and become northeasterly winds, and south winds would be deflected to the right and become southwesterly winds. (A wind is named from the direction from which it comes; *e.g.*, a northeast wind is one that comes from the northeast.) In the southern hemisphere, northerly winds would become northwesterly, and southerly winds would become southeasterly. And now on our imaginary spheroid there would be a system of atmospheric circulation such as is shown in Fig. 1384. Subject to the interferences introduced by the land and water surfaces and the irregularities of elevation of the former, this imaginary circulation is the actual circulation on our real earth. Bearing in mind the atmospheric conditions that would exist upon a homogeneous and smooth earth, we are prepared to see how these conditions are modified by the heterogeneous surface of our actual earth, and how the climate of any place is controlled by and may be predicted with more or less certainty from a knowledge of what we have called the climatic factors.

CLIMATIC FACTORS.—The general effect of these factors will now be briefly described.

Latitude.—Generally speaking, at the equator the sun's rays at midday fall perpendicular to the surface of the earth and their intensity is at maximum. North and south of the equator they impinge at angles that increase with the latitudes and they lose in intensity from two causes: first, because they are spread over a larger surface; and secondly, because they traverse a greater depth of air and lose energy from atmospheric absorption. With some slight modifications this explanation is applicable to the differences between the intensity of insolation at noon and that at other hours of the day. The following figure will illustrate these two facts. The same beam R, when the sun is vertical, is spread over a surface such as FF. When the sun is inclined at an angle as represented in the figure, the beam is spread over a surface F′F′, which is obviously greater than the first, and it passes through a column of air A′A′F′F′ greater than that of AAFF. The intensity of insolation at midday decreases approximately as the cosine of the latitude. If the solar radiation received in the average day at the equator be taken as unity and be called a thermal day, the annexed table will show the annual sum of solar radiation received at different latitudes:

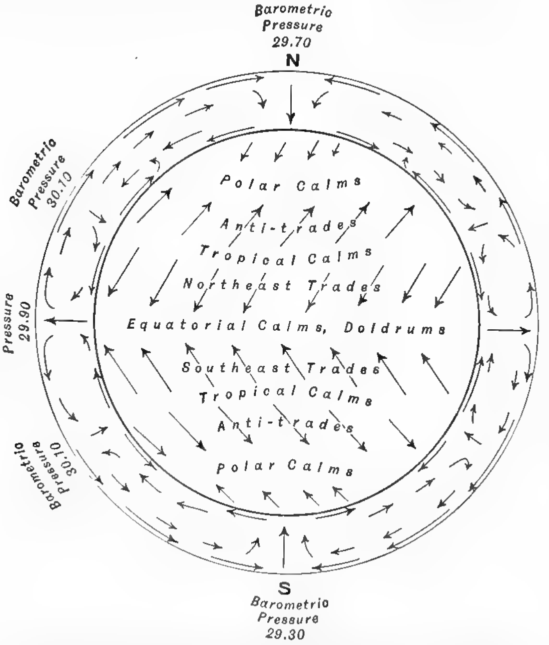
Barometric Pressure 29.70
N
Barometric Pressure 30.10
Barometric Pressure 29.90
Barometric Pressure 30.10
Polar Calms
Anti-trades
Tropical Calms
Northeast Trades
Equatorial Calms, Doldrums
Southeast Trades
Tropical Calms
Anti-trades
Polar Calms
S
Barometric Pressure 29.30

FIG. 1384.—Showing General Circulation and Direction of Atmospheric Currents. (After Ferrel.) Arrows in inner circle show the direction of the surface winds. Arrows within inner and outer circles show the scheme of the vertical circulation.

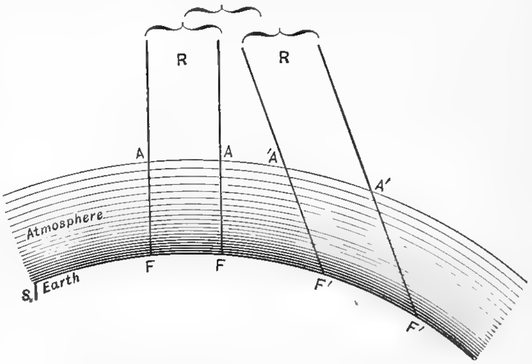

FIG. 1385.—Showing the Effect of Inclination on the Intensity of Insolation.

Latitude.	Thermal days.	Latitude.	Thermal days.
0	365.2	50	249.7
10	360.2	60	207.8
20	345.2	70	173.0
30	321.2	80	156.6
40	288.5	90	151.6

The amount of solar radiation also depends upon the length of the day. At the equator the days are practically of the same length and there is virtually no variation in the daily or seasonal amounts of insolation; but toward the poles the variation in the length of the day becomes very great, so much so as to overcome at certain seasons of the year the adverse effect of latitude. The following table shows the intensity of solar radiation on the 16th of December, the 16th of March, and the 16th of June, dates near the shortest, the average, and the longest days of the year, for each 10° north latitude. The figures express the intensity as a percentage of what it would be were the sun to remain vertical for twenty-four hours.

North latitude.	0°.	10°.	20°.	30°.	40°.	50°.	60°.	70°.	80°.	90°.
December 16th	0.30	0.26	0.22	0.17	0.12	0.06	0.02	0.00		
June 16th	.28	.31	.33	.34	.35	.35	.35	.36	0.38	0.38
March 16th	.32	.31	.30	.27	.24	.20	.15	.10	.06	

The eccentricity of the sun with respect to the centre of the earth's orbit is such that at the period of perihelion the effect of the solar energy is about seven per cent. more than at aphelion. As perihelion occurs in the summer time of the southern hemisphere, and aphelion in its winter, the seasons are much more extreme in that hemisphere than in the northern.

Altitude.—In climatology, altitude signifies vertical height above the level of the sea. The effect of altitude upon climate follows from its effect upon the mass of the atmosphere. According to the well-known law of Boyle, the volume of a given mass of gas will vary inversely as the pressure for all ordinary ranges of pressure, the temperature remaining constant. The stratum of air at 3.5 miles above the sea sustains only about one-half the sea-level pressure; accordingly, if the temperature remains constant, a given volume of air at the level of the sea if transported to this altitude would expand into two volumes. Conversely, a volume of air at this altitude would be compressed at sea level into but half its original volume. Under natural conditions when air expands freely, that is without doing work, it loses temperature, or, more correctly, its heat is employed in accomplishing the expansion, and becomes latent to the senses and to the thermometer. The opposite is the case when air contracts without doing work: that is, it gains in temperature, or it liberates the heat that was doing the work of expansion; this liberated heat becomes sensible. Alterations of the temperature of the air of this sort are spoken of as adiabatic cooling and heating; *i.e.*, cooling and heating without loss or accession of heat from outside sources.

The general effects of altitude upon the air may be briefly stated, with approximate accuracy, to be that the volume of a given quantity of air increases and its density decreases with the altitude; it decreases in temperature and loses more or less of its humidity by condensation and precipitation; its velocity increases, but its relative momentum decreases, it is more transparent, and offers less obstruction to insolation. The percentage composition remains unchanged, with the exception of the moisture as above stated. The following table shows the approximate decrease in atmospheric pressure for each 1,000 feet up to 10,000 feet.

Elevation above sea level (feet).	Barometric pressure (inches).	Elevation above sea level (feet).	Barometric pressure (inches.)
0	29.97	6,000	24.07
1,000	28.92	7,000	23.20
2,000	27.88	8,000	22.37
3,000	26.87	9,000	21.56
4,000	25.90	10,000	20.79
5,000	24.97		

Land and Water.—These two forms of the earth's surface are the perturbing factors of climate. As already pointed out, a homogeneous, smooth earth would have regularly distributed climatic conditions. The introduction of two kinds of surface, distinct in form and properties, and irregularly distributed with respect to each other, and in the case of the land irregular in its own surface, produces all the anomalies encountered in climate. A knowledge of the land forms and the relative positions and distributions of land and water is essential to the understanding of the actual climates of the earth. The disturbing influence of the land and water surfaces of the earth arises from the different specific heat capacities of these two surfaces and their different powers of conduction, convection, and radiation of radiant solar energy; also, from the rigidity of the one and the mobility of the other; and the general persistency of form in one, the land, and the duality of form (liquid and vapor) in the other, the water. Some of the effects caused by the irregularities of the land surface have been alluded to under altitude, and others will be mentioned under other heads. The specific heat capacities of land and water are about in the ratio of 1 to 4, that is, the same absolute amount of heat will raise the temperature of a land surface four times as high as it will raise that of a water surface. Land is a poor absolute conductor and a poor reflector of heat; it is a good absorber and a good radiator. From its poor conductivity the land retains its absorbed heat near its surface to be as quickly radiated as it was absorbed. Water is a fairly good reflector, and for this reason a considerable quantity of the incident insolation is reflected and exerts no influence upon the temperature of the water. Water permits a considerable part of the incident heat to penetrate it to a not inconsiderable distance. Comparatively little of the heat is absorbed by the immediate surface layer or by any other one layer; the absorption is distributed almost uniformly throughout the depth penetrated. A part of the heat absorbed is expended in evaporating some of the water, and causes no rise in the temperature of the water. The water is in continual motion, and so a further mixing of the layers at different temperatures and depths, and of the waters of different regions, takes place. The warm water in the equatorial regions, heated by the intense insolation of a vertical sun, flows poleward along the surface, and its place in the torrid zone is taken by the cooler waters from higher latitudes that flow equatorward as deep currents. The specific heat of water is great, greater than that of almost any other substance, hence it requires a great deal of heat to cause a perceptible increase in its temperature; *per contra*, it may radiate a great deal of heat without sensibly lowering its temperature. From the operation of all these factors, a water surface maintains a more uniform temperature than does a land surface. It is never as hot in the summer and never as cold in winter. A certain amount of evaporation takes place from all land surfaces not absolutely dry; but the amount is extremely small compared with the distillation that goes on from a free water surface. As a consequence, the atmosphere over the latter contains always more moisture (the temperature being the same) than the former, and clouds and precipitation are more frequent as a rule.

Mountain Ranges.—The influence of mountain ranges is seen chiefly in their effects upon the rainfall and the prevailing winds. These effects will be more or less general or local according to the height and direction of the mountains with reference to the general atmospheric circulation of the latitude. If a range runs transversely to the prevailing winds, it will either deflect them from their course or force them into higher altitudes. In the former case the range will serve as a wind break to the regions on its lee side and will send the winds into other regions from directions other than they would have come. Most important consequences arise from this fact. The late distinguished American meteorologist, Prof. William Ferrel, has pointed out that the high tablelands and mountains of Mexico deflect the winds of the northeast trade zone toward the north over the southeastern United States and up the Mississippi valley into higher latitudes. "This," says he, "completely breaks up the tropical calm belt and dry zone, so that instead of a dry region with scanty rainfall, such as is found in North Africa, Arabia, etc., . . . we have a region of abundant rainfall, and all the way up the Mississippi valley and in the interior of the continent there is much more rain than in the interior of Asia." When a wind is forced up a mountain it cools by expansion, or adiabatically, and more or less of its moisture is precipitated on the mountain sides and top. On the lee side of the mountain it descends and its temperature is raised by compression, again adiabatically. As the air in its passage up the mountain has lost the greater part of its moisture by precipitation, in its descent on the lee side of the mountain its temperature is raised to a higher point than it was at the beginning of the ascent, because dry air has a less specific heat capacity than moist air. These facts are seen in the well-known phenomena of the Swiss *Föhn* and the American *chinook* winds. Mountain ranges that do not obstruct the prevailing winds of the region exert only local influences upon the climate of the region.

Ocean Currents.—The effect of ocean currents on climate may be inferred almost without further comment from what has been said regarding the difference of insolation on land and water surfaces. The chief effect of ocean currents is to temper the extremes of the shores that they wash, and this tempering effect may extend to a greater or less degree inland, depending on the greater or less elevation of the land near the coast and the prevailing winds of the region. The most notable illustration is seen in the effects of what is popularly attributed to the Gulf Stream, but which are really those of the general circulation of the North Atlantic Ocean. By this circulation the warm water from the tropics is carried northeastward to the shores of Iceland and Northern Europe, rendering habitable, by the aid of the winds of those latitudes, which blow from the ocean, countries that would otherwise be as bleak as Labrador. The better-known ocean currents are, the Gulf Stream of the North Atlantic and the Kuro Siwo of the North Pacific, both warm currents, flowing from the tropics toward the cooler waters of the poleward regions. There are other warm currents less popularly known flowing from the tropical waters. There are also cold currents from the Arctic regions that chill the coasts of the countries they wash. A cold current flows from Davis Strait along the coast of Labrador and even farther southward, influencing the temperature of the coast as far as Cape Cod. Humboldt's, or the Peruvian, current from the Antarctic lowers somewhat the temperature of the Chilian littoral.

Prevailing Winds.—As climatic factors the prevailing winds are the agencies by which the inequalities in temperature and the other climatic elements that result from the effects and distribution of the land and water surfaces of the earth are maintained within a measure of equilibrium, which though varying in different regions, yet remain on the whole constant for each region. To understand the climate of a region, the direction from which the wind of that region comes must always be taken into consideration. If the wind comes directly from over a considerable body of water, it will bring with it in a greater or less degree the temperature and humidity of the air over the water surface. Should, however, a mountain range intervene, the wind would be robbed of the greater part of its moisture, but would retain its temperature, as already referred to under the effects of mountain ranges. On the other hand, if the wind blows from the land, it brings with it the climatic conditions of the surfaces which it traverses.

Winds are classified as permanent, periodic, and variable. The permanent winds are those of general systemic circulation that prevail over the disturbing effects of the land and water distribution. They are well represented in the trades and the anti-trades of the oceans. The periodic winds are characterized by their prevalence from one direction in one season, and from the opposite direction in the opposite season. The Indian monsoons are the most popularly known of this class. The variable winds are members of the cyclonic and anticyclonic circulation systems of the atmosphere. The prevailing winds of a region can be predicted from a knowledge of the position of the region with respect to the general system of the atmospheric circulation, previously indicated, and from the relative position and distribution of the land and water areas of the region, the topography of the region and the consideration of the season of the year, and, in some instances, of the time of the day. From the facts already developed of land heating and cooling more rapidly and more extremely than water, the atmosphere over the land is subjected to greater extremes of temperature and density than that over the water. Air moves in the direction of least resistance, that is, from the denser toward the less dense. In the case of continents these conditions give origin to the class of periodic winds known as monsoons, from the Hindoostanee signifying season. The monsoon results, in the summer, from the overheating of the air over the interior of a continent, its consequent expansion, loss of density, rising and overflowing as upper air currents toward the cooler region of the ocean and the inflowing as surface currents of the cooler air from the water to take the place of the former. This form of exchange keeps up during the summer months. In the winter months the conditions are reversed. The air over the ocean is warm, that over the interior of the continent cold, for reasons that have been explained, and the exchange takes place just the opposite of that in summer. When the monsoon wind is in the direction of the general circulation of the latitude, it adds its force to that of the latter, which appears as a stronger wind than normal. If contrary, the monsoon must either overcome or be overcome by the general wind of the latitude. If the first, it appears as a feeble monsoon; if the latter, it is in evidence negatively as an enfeeblement of the systemic wind of the latitude. The effects of topography upon a monsoon can be inferred readily from what has been said regarding the influence of mountains on winds. Along the littorals of all large bodies of water a familiar illustration of the different effects of insolation on land and water is seen in a periodic wind of shorter period than the monsoon, the daily land-and-sea breeze.

The following broad generalizations as to the prevailing winds, and also ocean currents, of the globe may be of service. Within the warmer latitudes, the tropics and sub-tropics, the winds and ocean currents have a prevailing direction from the east; within the temperate latitudes, the winds and ocean currents have a prevailing direction from the west; within the polar latitudes, the wind and ocean currents have a prevailing direction from the poles toward the equator. There are a few winds that should be mentioned because of the frequent reference to them in climatic literature. These winds are all cyclonic in origin. The disagreeable *east wind* of Britain, referred to so often by Dickens in one of his novels, is dry and cold. The *mistral* of Southern France is a violent cold, dry, northwest wind, and is the *tramontana* of the Adriatic coast. The *northers* of Texas and the West are very cold and dry winds. The *scirocco* of the Mediterranean littoral is a torrid south wind, hot from the sands of the Sahara and damp from the moisture of the Mediterranean. The *khamsin* of Egypt, and the *Harmattan* of the west coast of Africa, are easterly and southeasterly winds, dry and hot from Sahara. The dreadful *simooms* of the Arabian and Persian deserts are but violent local whirlwinds, mixing the air and the heated sands of the desert together, with resultant temperatures that would be unendurable if continued longer than a few moments. The simoon passes over in about ten minutes.

Rainfall.—The effect of rainfall as a factor is rather passive than active. Rain itself is the result of the operation of the other climatic factors and elements. To save a certain amount of repetition, its further consideration is deferred to rain as an element of climate.

Soil.—The nature of the land surface, apart from the great irregularities that have been considered under mountain ranges, exerts a considerable influence upon the climate of the region. The physical construction and chemical composition of the soil affect in no inconsiderable degree the quantities of insolation and of moisture that remain for a greater or less time in its surface. The general relation of the kind of soil to the absorption and radiation of heat is approximately about as follows:

Absorption and Radiation of Heat in Percentage.

Sand, with some limestone	100
Pure sand	96
Light clay	77
Gypsum	72
Heavy clay	71
Clayey earth	68
Pure clay	67
Fine chalk	62
Humus	49

From this table it will be observed that a sandy limestone soil absorbs practically all the heat falling on it. The absorptive and the emissive thermal powers of a body being equal, it follows that the same soil radiates under given conditions all the heat it absorbs. Observation has shown that sandy deserts are subject to the greatest ranges in temperature. Earth containing much humus shows less range of temperature than any other kind of soil. The quantity of moisture taken up by the different kinds of soil varies greatly. Sand and sandy soils absorb moisture quickly and in great quantity, but retain it badly. Humus may take up from forty to sixty per cent. of its own volume of water and will retain it strongly. Rain falling, therefore, on sandy soil is quickly absorbed and quickly lost, the loss is mostly by percolation; falling on humus it is slowly absorbed, but what is taken is strongly retained. The damper the soil the more nearly it approximates the behavior of a water surface with respect to temperature and humidity. Frost

PLATE B.

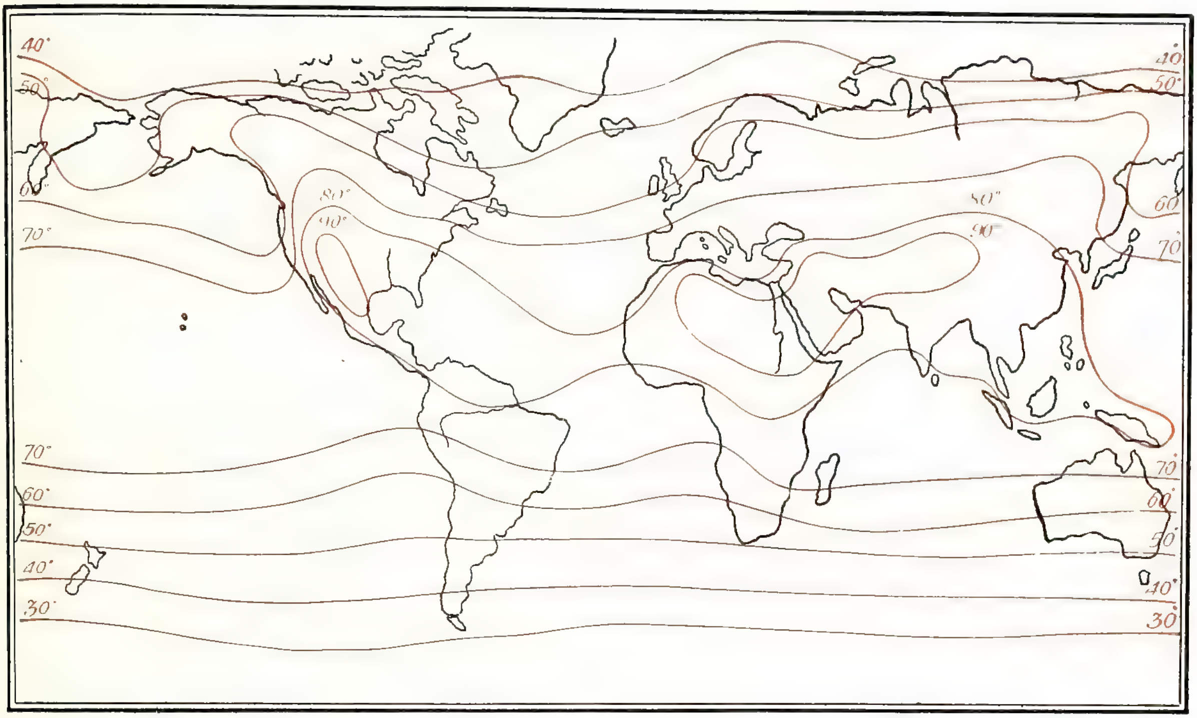

FIG. 1.

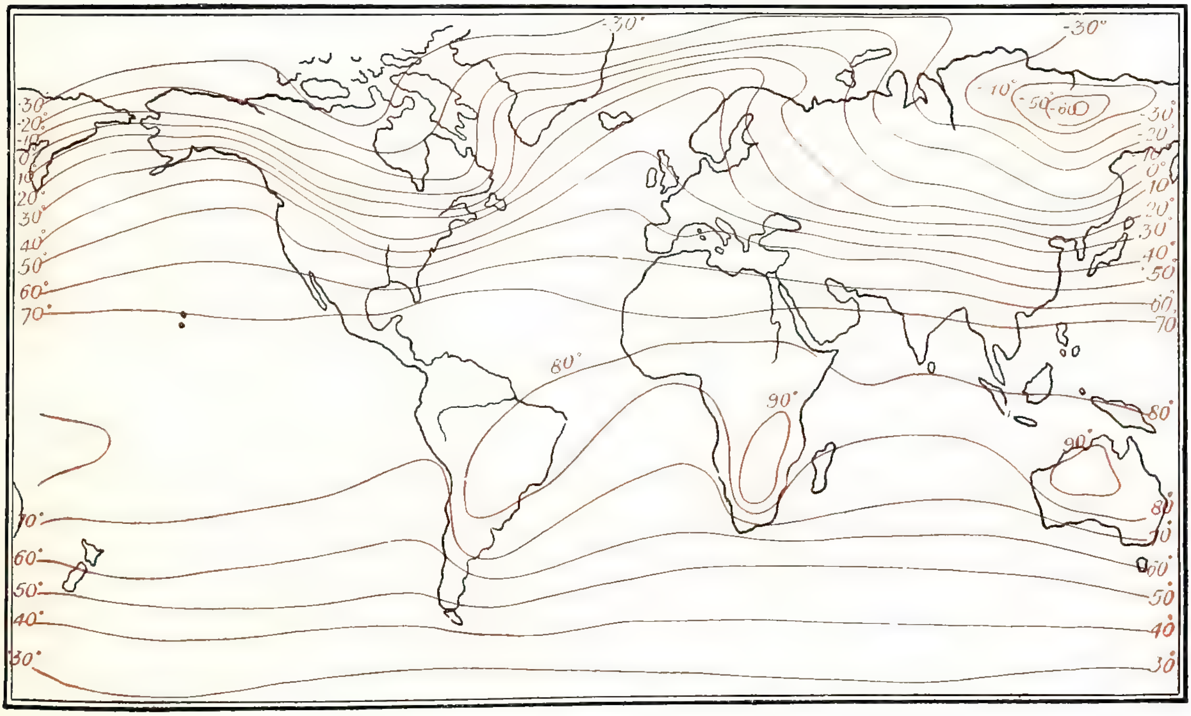

FIG. 2.

CHART OF ISOTHERMS OF THE WORLD

(Degrees Fahrenheit)

Fig. 1, for July; Fig. 2, for January.

does not form readily on marshy lands, while on well-drained lands it may occur on any night when the atmospheric temperature falls to 40° F. The damper the soil, the damper will be the atmosphere over it; the drier the soil, the drier the atmosphere—that is, so far as the moisture content of the air is dependent on the evaporation from the soil. Drainage of the soil will raise the temperature in the day and lower it at night. Water-logging will restrict both the day and the night ranges. Vegetation, though not strictly a part of the soil, is intimately associated with the latter and may be considered in connection with it. The effect of vegetation will depend upon whether it simply covers the soil as grass, or extends above and shades it as forest. The general effect of vegetation is to cool the soil by affording an increased radiating surface. Only a relatively small part of the foliage surface of plants is exposed to the sun's rays and absorbs heat, while all the foliage surface radiates heat; hence, the lower temperature of vegetation compared with that of the soil. In grass-covered fields the night temperature falls lower than in the forests; this is undoubtedly due to the interference with soil radiation by the elevated foliage. The average temperature, however, of forests is lower than that of woodless plains, but the temperature variations are less. The average humidity of the air of forests is usually about four to five per cent. above that of the open. The effect of forests upon rainfall is a much debated question, but the general consensus appears to be that deforestation decreases the amount, and that where treeless regions have been reforested the amount of precipitation has increased. That reforesting has an appreciable influence upon the surface run off of water, checking the rate, seems undoubted. Forests may serve to a certain extent as wind breaks. These influences are obviously local in operation. The effect of forests on the climate of a region in general is a matter awaiting further inquiry. The local slope of the ground has a considerable influence on the local climates of a region. A hillside sloping toward the sun receives the solar rays more nearly vertically than one sloping away from the sun. As a consequence the surface temperature of a sunward incline will be higher than that of an antisolar incline. The effect of inclination upon soil drainage is obvious and needs no comment.

Climatic Elements.—The items, or elements, of climate will now be considered briefly in detail.

Pressure.—Atmospheric pressure, though of the utmost importance in the causation and the explanation of the general and the local circulation of the air, is not usually classed among either the climatic factors or the climatic elements. It is not a climatic factor in the sense that latitude, or altitude, land, and water are, because it has nothing of their fixity. As an element of climate it is not perceptible to the senses like temperature, moisture, and the other climatic elements, hence it is generally left out of this category. Whether factor or element or neither, it is, however, a matter of importance to the student of climatology to know something of the general distribution and effects of atmospheric pressure. In the introduction to the general atmospheric circulation, the statement was made that in the region of latitude 30°, both north and south, there resulted from the banking up of the poleward moving currents a belt of high pressure that was sufficiently great to cause a poleward outmoving current at the surface strong enough to overcome the equator-seeking surface current from the poles. The pressure in this belt (speaking now of the one in north latitude) is not uniformly distributed around the earth. In winter, the pressure is greatest in those portions of the belt that cross the great continental areas of America, Europe, and Asia, and lowest in those over the Atlantic and Pacific Oceans. In summer, the pressure is greatest in those portions of the belt over the Atlantic and Pacific Oceans and lowest in those over the continents. This shifting of pressure gives rise to the monsoon winds; it is itself due to the unequal effects of insolation on land and water. In the southern hemisphere these changes are less striking, because of the relative preponderance in area of the water over the land, but they are still in evidence. As a climatic element the pressure changes from day to day are usually so slight that their effects escape detection except by closest observation. To a certain extent the effects usually attributed to altitude are those that belong properly to diminished atmospheric pressure.

Temperature.—If other influences be ignored, it may be stated that the temperature is highest under the vertical sun and decreases as the sun declines from the vertical. The rate of this decrease with regard to latitude has been explained and is, as previously stated, approximately as the cosine of the latitude. If we read altitude for latitude, the same ratio will hold good for the intensity of the insolation with a clear sky at any hour of the day. When the sun is just on the horizon its rays are tangent to the surface, and practically all its caloric radiant energy is absorbed by the great depth of the atmosphere through which the rays have to pass. As the sun rises above the horizon this depth of atmosphere becomes less and less, in the ratio stated, and less and less heat is absorbed, till under a vertical sun seventy-five per cent. of radiant energy, as heat, reaches the earth's surface. As the sun declines from the vertical the reverse operation takes place. Under the equator, or within the tropics generally, it is estimated that on a clear day sixty-five per cent. of the total radiant solar energy incident on the outer limits of the atmosphere reaches the earth's surface. From the different effects produced by the solar rays on land and water, taken in connection with the great increase in the length of the summer day (that is, of the time the sun is above the horizon) in the higher latitudes, one is prepared to understand that the highest temperatures are not necessarily confined to the tropics. The lengthened sunlighted day of the summer in extra-tropical regions, and the relatively great absorption of heat by the land, cause the temperature of the continents in these regions to be from 10° to 20° F. higher than the theoretical normal for their latitudes. On the contrary, the long nights of these regions in winter and the enfeebled insolation due to the low meridian altitude of the sun, and also to the great radiating powers of the land, bring the temperature of these continental areas correspondingly below their theoretical normals. The following table, calculated by the late Prof. William Ferrel, shows in F. degrees the average temperature over the combined land and water surface for each tenth parallel as far as 80° north and 60° south latitude, for January, July, and for the year.

Latitude.	Temperature.		
	January.	July.	Mean of Year.
North 80°	−25° F.	34° F.	4° F.
" 70	−16	44	14
" 60	−2	57	29
" 50	21	66	43
" 40	40	73	56
" 30	55	80	68
" 20	71	84	78
" 10	79	83	81
" 0	81	79	80
South 10	82	75	79
" 20	80	69	75
" 30	73	60	67
" 40	64	52	58
" 50	52	44	48
" 60	38	32	35

The approximate actual distribution of temperature around the world for January and July, as deduced from the accumulated meteorological records of the world, is shown in the two accompanying charts (Plate B). A comparison of the deflection of the actual isotherms from the position of the calculated isotherms shows most strikingly the effects of the different climatic factors. The influence of the ocean currents and the general heat-retaining properties of water cause the extra-tropical parts of the great oceans to be from 5° to 10° F. cooler in summer than the calculated normals for the latitudes, and from 10° to even 40° F. warmer in winter, as in the North Atlantic. The interior of continents is subjected to the greatest extremes of heat and cold, while the temperature of their shores may be greatly modified by that of the surrounding oceans. Though many irregularities exist in the falling-off of temperature with increasing latitude, nevertheless the decline is positive. But latitude is not alone necessary for low temperature; even under the equator, if the elevation be sufficient (about fifteen thousand feet), freezing temperatures and snow may be found. Going toward the poles this elevation declines till at the Arctic circles it is at sea level. The line of the altitudes of this freezing temperature in the different latitudes is called the snow line. In the free air, the temperature falls about 1° F. for every three hundred feet ascent. In ascending high mountains, the decline is slightly less. Over elevated plateaux the fall in temperature due to the altitude of the region is very much less, not more than 2° to 3° F. to the thousand feet, and this amount varies with the season, being less in summer and greater in winter. In estimating, therefore, what will be the decrease in temperature due to the altitude of a place, regard must be had to whether it be a rapidly rising mountain or a slowly rising plain.

The temperature of the air is controlled more or less in its degree and in its fluctuations by the state of the atmospheric humidity. Water in the gaseous state is as diathermanous as dry air; but when condensed as cloud, even though the condensation be too slight to be visible, it offers great obstruction to the passage of heat. Hence in cloudy regions, and on cloudy days, the temperature is usually more uniform, that is, it is subject to less pronounced extremes of heat than it is in clearer regions or on cloudless days. Air expands or contracts $\frac{1}{491}$ of its volume for each change of 1° F. Warm air is, therefore, lighter and rises; cold air, heavier and falls. The effect of this is seen in the phenomena of hill and valley winds. In the daytime the warm air flows up the hillside, and at night the cool air flows down the slope into the valley, where it is felt sometimes as an intensely cold wind. These cold night winds are very common in the deep valleys of the Swiss Alps. The average temperature of the air is highest both seasonally and diurnally, not at the time of the greatest solar altitude, but at a period a little subsequent thereto. The warmest part of summer is about a month after the æstival solstice; and the warmest part of the day is about one or two hours after noon. The coldest part of the winter is about a month after the winter solstice, and the coldest part of the day is about an hour before sunrise.

Humidity.—The relation between temperature and humidity is an intimate one. The amount of water that can exist in the gaseous state depends on the temperature. The higher the temperature the greater the possible humidity; the lower the temperature the lower the possible humidity. Water exists in the gaseous state at all observed temperatures. The following table shows the actual weight of water that can exist as a gas at some of the ordinary atmospheric temperatures:

Temperature.	Number of grains of aqueous vapor in a cubic foot.	Temperature.	Number of grains of aqueous vapor in a cubic foot.
100° F	19.8	30° F	1.9
90	14.8	20	1.2
80	10.9	10	.8
70	8.0	0	.5
60	5.7	−10	.3
50	4.1	−20	.2
40	2.8		

The amount of moisture in the atmosphere in any given locality will be governed, first, by the temperature of the region; secondly, by the nature of the evaporating surface of the place, whether land or water; thirdly, by the rate at which the humidity is carried away; and finally, by the rate at which humidity is brought to the region by the prevailing winds. As the temperature declines with altitude, it is evident that the humidity possibilities of elevation must likewise decline. The humidity of the atmosphere is referred to under two captions, absolute and relative humidity. By absolute humidity is meant the real amount of water existing as vapor in a unit of space. In English measures this amount is stated usually as grains of water per cubic foot. The table just given shows the absolute humidity in a saturated cubic foot at the temperatures indicated. By relative humidity is meant the ratio that the amount of vapor actually present bears to the amount required to saturate the space at the given temperature. Relative humidity is usually stated as a percentage, saturation being taken as 100. Absolute humidity is a physical entity. Relative humidity is simply a relation between the temperature and the absolute humidity. The statement of the relative humidity conveys no practical information unless the temperature or the absolute humidity be given also. The absolute humidity of the air, though limited in its quantity by the temperature, varies but slowly from day to day and from season to season. The variation is less with a rising temperature, because the increase of temperature does not affect in any way the form of the humidity. But as the temperature falls a point is reached when the space will be saturated, and then a change of form of the moisture takes place, condensation occurring, and heat, the so-called latent heat of evaporation, is set free, which raises the temperature somewhat and checks its fall for a while. This process may go on indefinitely till either the moisture be all precipitated or some accidental cause comes in to raise the temperature. This fact of moisture liberating heat during condensation is an important factor in the retardation of cooling. In passing from the liquid to the vapor state, water takes heat from the surroundings; that is, evaporation lowers temperature.

The amount of evaporation depends on the temperature of the space into which the vapor escapes. The higher the temperature of the space the more vapor it can contain. The rate of evaporation depends on the temperature of the evaporating surface, the humidity, and the velocity of the wind. The temperature of the evaporating surface determines the velocity with which the vapor molecules escape from the surface; the higher the temperature the greater the velocity. The lower the atmospheric humidity the more rapidly will the molecules escape into the space, and the higher the velocity of the wind up to a certain limit the more rapidly will the escaped molecules be removed out of the way of others.

It is customary to say that the atmospheric pressure influences the rate of evaporation; this is only true if by it we mean the partial pressure of the aqueous vapor in the atmosphere. Water evaporates in a dry atmosphere of oxygen or any other dry gas under twice the ordinary barometric pressure as rapidly as it does in one of like kind under but one-fourth the same pressure. It is the pressure of the water vapor that controls the rate of evaporation, for the well-known physical fact that all gases are to each other as vacuums holds good with regard to the gases of the atmosphere. The fact that evaporation is usually more rapid in elevated regions is simply due to the lesser atmospheric moisture of these regions. The wind facilitates evaporation by removing the layer of vapor formed over the evaporating surface, thereby lessening the vapor pressure on the surface. Under the most favorable conditions, a certain definite time is required to convert water into vapor. When the velocity of the wind reaches a rate of movement equal to the rate of vapor formation, no further increase in the movement of the wind affects the rate of evaporation. This velocity is about thirty miles per hour; that is to say, that wind velocities of more than thirty miles per hour have no more effect on the rate of evaporation than a thirty-mile wind has.

The following table shows in inches the average depth of water evaporated annually from a free water surface at several places where such records have been kept:

Place.	Latitude.	Evaporation.
Madras	13 N.	91
St. Helena	17 S.	84
Dijon	47 N.	26
London	51 N.	21
Boston	42 N.	39
Lake Michigan	44 N.	22
Great Salt Lake	41 N.	80
Fort Conger	82 N.	9

The atmosphere contains always more or less foreign solid particles, or dust, which radiate their heat during the night more rapidly than the air. The temperature of many of these particles will generally fall below that of the atmospheric dew-point at the time—that is, the temperature at which the air would be saturated with moisture. As a result vapor will condense upon them, they will become heavier and heavier, and many of them will fall to the ground. The occurrence of this phenomenon explains why the air is, as a rule, so much clearer in the mornings than at other parts of the day.

Wind.—The movement of the atmosphere, or simply the wind, results from a difference in the density of the atmosphere. The wind is merely the effort to restore or maintain an equilibrium. The atmospheric density is disturbed in two ways: by difference in temperature and by difference in humidity. The effect of temperature on the density of the air has been mentioned. Aqueous vapor is specifically lighter than either oxygen or nitrogen, the two chief constituents of dry air; hence an equal volume of moist air is lighter than a like volume of dry air, temperature and pressure being equal. The movement of the air is impeded by friction at the surface of the earth; and it increases with elevation up to a certain height.

Atmospheric movement is of two kinds, vertical and horizontal; the latter are those familiar to us as winds. The vertical circulation is, however, an important element. It is by the vertical movement of the air that the uniform ratio of mixture of the different permanent gases of the atmosphere at all observed elevations is maintained. The upward vertical movement is greatest in the region of the equatorial calms. A downward vertical movement takes place in the region of variable winds about latitudes 30°, also in the regions of the poles. The winds are generally stronger during the day and increase in velocity up to noon or a little after, and then decrease gradually to a minimum during the night. This does not apply, of course, to the wind velocities of accidental storms.

Electrification.—As an element of climate the electrical state of the atmosphere deserves mention; but as to its effects little can be said. The atmospheric electrification is, as a general rule, positive with respect to that of the earth, but it is subject to great and sudden variations. During rain storms the atmosphere is often if not generally negatively electrified. There appears reason to think that the atmospheric potential of elevated regions is greater than that of sea-level regions.

Sunshine or Sunlight.—The effect of the sun cognizable as light undoubtedly is a most important consideration in climate in relation to the organic world, but as an item of the state of the atmosphere sunlight is not appreciable. What impress it may make or leave upon the air is yet to be ascertained. As a climatic element, it is measured by its photographic effects. Observation has shown that the photographic effects are stronger in summer than in winter, and in the forenoon than in the afternoon. This is probably the result of the greater freedom of the air from clouds and dust in the morning hours, and to the lessened atmospheric depth traversed by the light rays in the summer.

Rain.—Like sunlight, rain makes no continuous impress on the atmosphere. It cannot be regarded strictly as an element, yet it performs an important function in the purification of the air. According to the researches of Aitkin and others, the formation of rain begins by condensation on the dust particles of the atmosphere; in falling to the earth, rain washes down many more; this is why the air is always clearer after precipitation. Rain also brings in solution some of the constituent gases of the air. An important one, and one that exists in such small quantities as to be characterized in amount by the chemist's "trace," is ammonia. But small as is the ammonia content of the air, it is indispensable in the vegetable economy. The relation of rainfall to the humidity of the air is almost that of effect and cause; without sufficient humidity, rain cannot occur. The time of rainfall varies with the cause of its precipitation. Within the tropics, rain falls most often in the afternoons and in the form of heavy downpours. Shortly after the precipitation ends the clouds break up and disappear, leaving the nights cloudless. In the extra-tropical regions, when the rain comes as one of the consequences of a thunder storm, it is most frequent in the afternoons. In the rains of cyclonic storms, the precipitation may, and does, occur at all hours of the day. The clouds do not break up, as a rule, till some time after the rain has ended, except in the case of thunder storms, after which the clearing is generally more rapid.

The seasonal distribution of rainfall is a most important climatic consideration in connection with vegetation and habitability. Many regions having comparatively large amounts of rainfall in the year are yet unsuitable for vegetation, because the precipitation either does not fall during the spring or summer seasons, or falls all in one or two torrential downpours, instead of being distributed in smaller quantities over the growing season. On the other hand, regions that have but a comparatively small yearly rainfall are yet fertile because the precipitation occurs during and throughout the growing seasons.

The present knowledge of the causation of rain may be summarized as follows: To produce abundant rain the temperature of the air must be suddenly brought below that of the dew-point. Air cooled below its dew-point condenses its moisture into minute cloud or fog particles. These particles may float away or be re-evaporated should some cause raise their temperature; or, if in sufficient number and in such motion as to bring them into collison, they may coalesce and form larger and larger drops till they attain sufficient weight to overcome the atmospheric resistance and fall to the ground as rain, snow, or hail, according to the temperature and conditions of condensation. This cooling of the air may be effected, so far as present knowledge goes, by the air being forced up the side of a mountain, as happens when a mountain runs transversely to the direction of the wind; the surface air may become, under the effects of intense insolation of a region, warmed to a degree that will cause it to expand rapidly and thus give rise to ascensional currents, which carry the moisture upward till its dew-point is reached, with resulting condensation and precipitation; and lastly, but most important, at least outside the tropics, by the circulation of the air in cyclonic storms in which there is a surface inflow radially from all sides and a central ascensional movement.

The following broad rules are convenient as indicating the general distribution of rain: Rain is more abundant in warm than in cold countries, that is, its quantity decreases from the equator toward the poles. Rain is more abundant in coast regions than in the inland countries; provided that there be no mountains, or the mountains be far in the interior. Rain is more abundant in hilly and mountainous districts than in lowland regions. Rain is more abundant on windward shores and exposures than on leeward shores and exposures. Rain is more abundant in summer than in winter. It increases in amount up to 5,000 feet above sea level; above this altitude it begins to decrease. Rain in falling washes down many of the impurities, especially dust particles, floating in the air. Regions that have frequent rains have clear and clean atmospheres. The humidity of the air is always greater for some time after a rain because of increased surface evaporation.

Comparative Climatology.—Having sketched what climate is, and how it is primarily dependent upon solar radiation, modified by the agencies called in this connection climatic factors, we should next consider how we may best obtain a knowledge of the difference between the actual climates of the different regions of the earth's surface. The practice of classifying climates is an attempt at the solution of this difficult problem, for difficult problem it is, and will be so found by any one giving careful thought to the subject. Climates are classified variously. There is no definitely settled system, the deciding influence being that of the purposes the system is intended to subserve or illustrate. They may be classified with reference to their relative insolation, as solar or astronomical climates; or with reference to the general characteristics impressed on them by the two grand divisions of the earth, as land and water, or continental and marine, climates; or with reference to the possession in greater or less degree of some particular physical property, as heat, moisture, etc.; and finally, with regard to their physiological effects, as relaxing, invigorating, rigorous, severe, etc. The following schema will show in a measure some of the possibilities of climatic classification, and will suggest combinations that may perhaps be found more applicable to any particular purpose the reader may have in view:

Classification basis.	Sub-divisions under classification.	General characteristics of each subdivision.
Solar or astronomical.	Tropical ...	Usually mild, equable, moist, warm, average temperature 80° F. Rainfall frequent and heavy over water and over windward land exposures. Nights usually clear, afternoons cloudy. No general storms. Seasons, rainy and dry; but this division is only a relative one.
	Temperate..	Unsettled weather, great and variable changes in temperature, rainfall, and moisture from season to season and day to day. Region of cyclonic storms, cold and hot waves, floods and droughts.
	Arctic......	Cold; temperature on average considerably below freezing. Scanty rainfall. Very short but hot summer. Winter long and severe. Storms infrequent.
Geographical.	Continental	High temperature in daytime, low at night. Difference between day and night temperatures increases toward centre of continent. Great variations in temperature, sometimes hot, sometimes cold. Moisture variable from almost saturation to aridity. Rainfall subject to great variations and extremes. General tendency to extremes in all climatic elements.
	Oceanic....	Temperature equable, range between day and night hardly exceeds 2° to 4° F. in mid-ocean. Moisture high but constant. Rainfall frequent.
	Insular and littoral...	Intermediate between above, partaking more or less of the characteristics of one or the other.
Topographical (land).	Plain.......	Extremes of temperature great, rainfall uncertain, humidity low.
	Hill........	Extremes of temperature less than plain, rainfall greater, humidity higher.
	Mountain...	Generally same as hill, except effects of altitude become more evident; rainfall increases up to about five thousand feet, then decreases.
	Valley......	Extremes of temperature greater than hill. Humidity greater; rainfall greater than plain.
	Desert.....	Rainless; great extremes of temperature between night and day and season and season.
	Artificial...	Such as climates of large cities. Temperature of cities always higher than surrounding country; haze and cloud and fog more frequent.
Aerophysical.	Temperature......	High Intermediate Low according to the degree of heat adopted as the standard of comparison.
	Humidity..	Damp or moist Intermediate Dry or arid according to standard of humidity adopted.
Physiological.	Invigorating....... Relaxing.. Rigorous, etc.......	According to the general effects of the particular climate.
	Mild....... Pleasant... Humid..... Disagreeable, etc..	According to the general sensation produced, etc.

Exact physical measurements of the climatic elements and the effects of the climatic factors are essential to the scientific understanding and utilization of climate. How these elements and factors shall be measured and recorded is a question of the first moment, and one of the most difficult to formulate a satisfactory answer for. What would be a satisfactory determination of climate to the pure meteorologist would probably be unsatisfactory in a greater or less degree to the student of climate in its application to other subjects. The botanist, the zoologist, the physiologist, the sociologist, etc., each and all have a different view of climate, and each would measure it in terms not altogether applicable or best suited to the purposes of the others. To measure and record climate in a manner such that each inquirer would find what he looked for and in the shape in which it was wanted, would obviously be a task of magnitude. But, great as would be the undertaking, should any one desire to attempt it, a greater difficulty would be encountered in deciding what was suited to each interest. The discussion of this aspect of the question cannot be opened in this article. For the present, climate is for the most part measured and recorded as the student of meteorology conceives it serviceable and appropriate to the purposes of his science. Taking the climatic statistics as they are generally recorded, the question, however, becomes pertinent how to present them to the best possible advantage for the purposes of general information. Ordinarily these statistics are given in terms of their average values for a period of years. In some respects this kind of climatic information is useful and even indispensable; but it by no means conveys an adequate conception of the weather conditions that may prevail in the regions the statistics represent.

The method of averages, as is well known, smooths out, or masks, irregularities and extremes. The climate of a region is more important in respect to the extreme limits within which the values of its elements fluctuate than in the mean between these limits. The average temperature of two places may be the same, and yet, so far as the distribution of their temperatures either throughout the year or through shorter periods is concerned, they may differ to such an extent as to be unrecognizable when viewed in the light of the total effects of their respective temperatures. As concrete illustrations of this fact there may be cited the mean temperatures of two places in the United States each having the same yearly average of 49° F., viz.: Des Moines, Iowa, and Tatoosh Island, Washington. The average temperature of the warmest month at Des Moines is 75° F., at Tatoosh Island 56° F.; the averages of the coldest months are 18° F. and 41° F., respectively. The temperature at Des Moines has been observed as high as 104° F., at Tatoosh it has never been observed above 78° F. At Des Moines, the lowest recorded temperature was 30° F. below zero; at Tatoosh, 7° F. above zero. The total range of temperature observed, that is, the difference between the highest and lowest temperatures, was 134° F. at Des Moines, and but 85° F. at Tatoosh. Averages may thus be very misleading. Although the mean yearly temperatures of England and of New York are the same, Indian corn will not mature in the former, but does ripen readily in the latter, and all because the summer of England is cool and that of New York warm.

The following table compiled for the city of Washington, D. C., from the records of twenty-six years, 1871–96, shows what in the writer's opinion is a very concise method of presenting meteorological statistics for conveying a fair idea of the climate of a place: what kind of weather is ordinarily to be expected, and what kind of weather may occur:

WASHINGTON, D. C., RECORD OF TWENTY-SIX YEARS, 1871–96.

Climatic conditions.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Temperature (Fahr.)—												
Mean or normal	33°	36°	41°	53°	64°	72°	77°	74°	68°	57°	45°	36°
Normal maximum	41	44	50	63	75	83	86	84	78	66	53	44
" minimum	26	28	33	43	54	63	68	66	59	47	37	29
" variability *	6	7	6	5	4	4	3	3	4	5	5	6
Warmest month—												
Year	1890	1890	1878	1878	1880	1874	1876	1872	1881	1881	1896	1889
Degrees	44	43	49	58	70	78	81	79	77	63	51	46
Coldest month—												
Year	1893	1885	1885	1874	1883	1878	1891	1874	1871	1876	1880	1876
Degrees	25	27	34	48	59	69	72	72	62	51	40	26
Highest—												
Degrees	76	78	83	93	96	102	103	101	104	92	80	73
Day	12	23	22	18	26	9	18	13	7	3	13	4
Year	1890	1874	1894	1896	1880	1874	1887	1881	1881	1879	1879	1893
Lowest—												
Degrees	−14	−2	4	22	34	46	53	49	38	26	12	−13
Day	1	5	4	19	1	1, 6	20, 22	24	26	31	22	31
Year	1881	1886	1873	1875	1876	1873 1894	1890	1890	1879	1893	1880	1880
Frost—												
Average date first killing frost (in autumn)—												
Day	....	....	....	....	....	....	....	....	....	22	....	....
Average date last killing frost (in spring)—												
Day	....	....	....	14	....	....	....	....	....	....	....	....
Humidity—												
Normal relative	77%	70%	66%	64%	69%	70%	71%	74%	76%	73%	72%	72%
" absolute, in grains per cu. ft.	1.6	1.7	1.9	2.9	4.4	6.1	6.7	6.5	4.5	3.4	2.4	1.8
Precipitation in inches—												
Average monthly	3.50	3.31	4.08	3.16	3.90	4.29	4.84	4.44	3.82	3.27	2.88	3.01
Average number days 0.01 inch or more	12	11	12	11	12	11	11	12	9	9	10	11
Greatest monthly—												
Year	1882	1884	1891	1889	1889	1883	1886	1875	1876	1885	1877	1878
Amount	7.09	6.84	8.84	9.13	10.69	8.55	10.63	12.93	10.81	8.69	7.18	4.94
Least monthly—												
Year	1872	1872	1894	1896	1875	1873	1872	1892	1884	1874	1890	1889
Amount	.23	.93	.98	1.07	1.01	1.63	.82	.85	.14	.29	.79	.19
Greatest amount in twenty-four hours—												
Amount	2.28	2.29	2.79	3.21	3.50	4.16	5.80	2.84	5.66	3.98	2.83	2.70
Day	4	5–6	9	26	7–8	22	29–30	29	15–16	4	24	17
Year	1886	1896	1881	1889	1886	1886	1878	1875	1874	1877	1877	1888
Greatest amount snowfall in twenty-four hours—												
Amount	5	10	6	4	....	....	....	....	....	†	2.5	10
Day	12	3	11	6	....	....	....	....	....	23	5	26
Year	1893	1886	1888	1889	....	....	....	....	....	1889	1891	1890
Weather—												
Average number of days—												
Clear	7	7	8	9	10	9	10	10	11	12	9	9
Partly cloudy	12	11	12	12	12	15	14	13	11	11	12	12
Cloudy	12	10	11	9	9	6	7	8	8	8	9	10
Wind—												
Prevailing	N. W.	N. W.	N. W.	N. W.	S.	S.	S.	S.	S.	S.	N. W.	N. W.
Normal velocity in miles per hour	6	6	8	8	6	6	5	5	5	6	6	6
Highest velocity—												
Miles per hour	46	60	48	43	54	48	60	53	66	51	54	49
From	N. W.	N. W.	N. W.	N. W.	S. W.	S.	N. W.	N.	S. E.	N. W.	S. W.	W.
Day	30	2	24	3	28	26	4, 28	5	29	4	23	9
Year	1894	1876	1878	1879	1896	1877	1874 1877	1878	1896	1877	1891	1876

* Variability of temperature is the difference between the mean temperatures of consecutive days, irrespective of the direction of the change. Average variability shows how much one day is likely to be warmer or colder than the day before or the day after it. † Trace.

Of course for special purposes, special arrangements of statistics and special computations are required, but the above table has the advantage that it can be taken almost without additional calculation from the ordinary meteorological records of a first-order station or observatory. Uniformity in the publication of climatic statistics, as in all other kinds, is much to be desired. But such a table as the above does not give all that is desired for a complete conception of the climate of a place. The average and extreme values for seasons and for shorter periods is required. The average diurnal hourly values for each month are important items. The number of days with temperatures below and above certain definite degrees, the number of hours of bright sunshine, etc., are also matters of importance. In fact, the fullest conception of a climate can be had only by going into great detail and by looking at the values of the climatic elements in a variety of ways. In the study of individual climates, those of small areas can be pursued by the statistical method, of which the above table is an illustration. But for the study of general climates this method is too laborious, and the less accurate but easier method of graphic representation is used. In some respects graphic methods are more impressive and more readily grasped, and for this reason are much employed wherever the matter lends itself to such treatment. The preceding charts (Plate B).

showing the distribution of temperature over the surface of the earth in the months of January and July, are illustrations of graphic or chartographic methods. These charts show at a glance the effects of some of the disturbing and modifying influences concerned in bringing about the very complex distribution of climate on the earth's surface. The elevation of the January isotherms on the northwest coasts of America and Europe is strikingly evident. This is due to the westerly winds and ocean currents of these latitudes. The depression of the July isotherms in the same regions is due to the same causes. In the winter the waters of the North Pacific and the North Atlantic are warmer than the land, in the summer they are cooler; hence the winds blowing from them to the land carry the climatic conditions of the oceans to a greater or less extent inland.

APPLIED CLIMATOLOGY.—The relation of climate to the organic world is one of the most interesting and at the same time intricate of the problems that present themselves for scientific investigation. The relation of climate to the distribution of organic life has been discussed from time out of mind, but beyond a few generalizations little has been yet found out. That climate does control absolutely in some way the forms of life scattered with more or less appearance of regularity over the earth is a proposition that is generally admitted. It is the foundation stone of the modern theory of evolution. Indeed, it would be most difficult for any one to refute successfully the claims put forward in support of climatic control. However, it must be admitted that it is impossible at present to express the geographic distribution of the organic world in terms of functions of climate. Whether it will ever be possible to predicate with scientific precision the peculiarities of form, habits, and health that will be the necessary outcome of a given climate cannot be asserted at present either positively or negatively.

Climate and Man.—If the presence of man only be considered, it will be found that he exists in all known climates, from the equator to the poles, from the hottest to the coldest, in the dryest and in the dampest, and in equable and in variable climates. So far as ability to live is concerned, man appears, at first sight, to be independent of his climatic environment. Yet such is actually not the case. By intelligent foresight man is enabled to combat more or less successfully effects that would otherwise overcome him. Virtually he makes for himself an artificial climate. Deprived of the means of surrounding his person with this artificial climate, he would be restricted to very narrow geographic ranges. By the addition of clothing, he conserves his body temperature when his atmospheric surroundings would dissipate it too rapidly. He re-enforces when necessary the protection of his habiliments by refuge in dwellings and by aid of artificial heat, both of which his ingenuity has devised. On the other hand, when his climatic surroundings, or the weather, go to the opposite extreme he constructs fans and punkahs to create artificial breezes, and he brings ice that has been stored from the previous winter, or made by his refrigerating machines, to cool himself. If the region produce not the food that he requires, he transports it from where it can be obtained, and he varies the quality of that of his own locality by importation from abroad. Should the resources at his command prove insufficient for health and happiness he migrates to climates more to his liking. That he has not reached the poles, or scaled the highest mountains, is not because he can not abide the climates of either. He has mapped out plans that would accomplish these objects with certainty, but it requires the energy of more than a few hardy adventurers to carry them into execution. The human body has, however, a great natural tolerance for both heat and cold. Jacobabad, in India, is a city of 5,000 inhabitants, and its average July temperature is 96° F., but two degrees less than that of the human body. The United States Weather Bureau maintained from May to October, 1891, a station in Death Valley, Cal., and the observer, Mr. J. H. Clery, spent July and August in that place with mean monthly temperatures of 102° F. and 101° F. respectively. The inhabitants of Verkhoiansk, in Northern Siberia, endure a midwinter temperature of 60° F. below zero, or 92° below freezing. In ordinary winters of the temperate zones, quite frequently man passes suddenly from a warm room at 75° or 80° to the outdoors with maybe its temperature of zero or below. He lives in the deserts of Arabia and Africa, where clouds are seldom seen and rain more than once or twice a year is an unusual occurrence; and he flourishes in the tropical islands where rain and cloud are daily phenomena, and in the Khasia hills with their nearly five hundred inches of rain a year.

Different races are endowed with different degrees of climatic resistance. The Eskimoes, living in the cold and cheerless north, wrapped in skins, and huddled in ice dens as houses, find life outside of the Arctic circle almost unendurable. The Latin races of Europe live readily in the tropics where the Teutonic stock must struggle incessantly for existence. The Chinese may be found living easily from Manchuria to Australia. The Jew lives everywhere. He is as much at home in the climates of Siberia as in his native Palestine, and he is found from Cairo to the Cape. The Ethiopian can live in the hot jungles of the torrid zone, but finds it hard to flourish in the temperate climates of the northern United States. All this shows that it is not so much the climate as it is the man and the race. It is the personal equation of living after all, the habits and modes of life, that account for this varied tolerance. Climate places its imprint upon social life and customs, and long usage makes it hard to abandon them, even when reason and experience show their evil effects. The average Caucasian carries with him to the tropics the same habits of life, food, and drink, and even clothing, that he has acquired in the colder north, and then wonders at his inability to become acclimated in the torrid zone. In the deserts and on the great treeless plains where water and grass often fail, man becomes a nomad, driving his herds and flocks from place to place in search of sustenance. In the forest regions he fells trees and builds a cabin or a kraal, and lays the foundation of a permanent home. The character of the climate affects the habitation he erects for his use. Under the hot sun of the tropics his house is low and open, the shade is sought and every breeze courted. Farther northward the house grows higher and the openings are fewer and fewer. From wood and open construction it passes to brick and stone, and compact structure; and every device that promises to keep the outside climate out and the inside climate in is sought for. Still farther north, because it is hard to heat a large building in the intense cold of the Arctics, the house becomes smaller, and from the modern sky-scraper, with its furnaces, fans, and electric lights, and its other numerous conveniences, it descends to the small dugout, and the ice-cabin, wherein human beings huddle together for warmth from each other's bodies, the only sufficient source of heat at their command.

Climate leaves its impress even upon fiction and history, upon poetry and prose, religion and superstitions. To the wandering Bedouin, he who dug a well was a benefactor; paradoxically the well was the monument of a philanthropist. To die of thirst with water vanishing ere it touches the parched lips is the Arab's direst curse, and green trees and running waters his ideal of paradise. In the colder north, where the sufferings from cold and want of heat are felt, demons in red, with heated forks and fiery furnaces, terrorized the wicked and restrained the good, and the halls of Valhalla were the hope of a hereafter. Upon the features climate perhaps has an influence, but the periods required for many changes are relatively so great that we cannot measure them. Within historic times there is no evidence of ethnic change. The Ethiopian of to-day is the Ethiopian upon the bas-reliefs of Nineveh and Babylon. And the modern Egyptian fellah wandering about the streets of Cairo was depicted in the reign of the Pharaohs.

From the influence of climate on man's modes and life, it follows that directly or indirectly climate must exert a profound influence upon his physical well-being. Abundant evidence of this influence is seen in the geographical distribution of certain diseases and their behavior when transported by commerce and migrations to other regions. Cholera and yellow fever are endemic within the sea-level altitudes of the tropics. Both occasionally are carried by agencies beyond their indigenous climates, and both after a greater or less time disappear completely from their new homes. The former lives longer out of its native habitat than the latter, which vanishes with the first air temperature of 32° or lower. Malaria is a widespread disease extending geographically on each side of the equator to the limits of the isotherm of 60°; beyond this it is not known to originate. Some forms of disease, as diphtheria, pneumonia, phthisis, rheumatism, nephritis, and others, show no definite climatic limits, and may apparently originate in any locality. Sunstroke, frost-bite, snow-blindness, and mountain sickness are perhaps the only ones that can be said to be caused by the climatic conditions under which they develop. The most important influence of climate is that which it sustains as a predisposing agent. The manner in which this influence may be exerted will depend upon the nature of the disease.

Modern research warrants the classification of disease into two general categories, viz., infectious and non-infectious; the germ diseases and the non-germ diseases. Of the first class, obviously those diseases that result from the presence of the strictly obligate parasites can be affected solely through the medium of the host; and so we find the diseases from such germs everywhere that the diseased host may migrate and live. Among this class are rabies, syphilis, and gonorrhœa. Upon the exciting causes of these diseases climate has no opportunity to act directly. Upon obligate parasites, but those of greater resistance, and which may exist for some time outside of the animal body, but which probably do not lead a saprophytic existence, there is opportunity for climatic effect. To this class belong the germs of diphtheria, glanders, variola, measles, and scarlatina. And there is some reason for supposing that the variations in virulence manifested in the different epidemics of these diseases are partly due to such causes. Upon the facultative saprophytes and the facultative parasites there is abundant opportunity for the effects of meteorological agencies. Under one or the other of these classes are the germs of phthisis, anthrax, typhoid, cholera, tetanus, yellow fever, and the various pyogenetic microbes. And, again, the evidence of variation in malignancy of these diseases can be accounted for, at present at least, only on the supposition of some favorable or unfavorable meteorological influences. Further corroboration of the probability of such suppositions is furnished in the experiments that have been made by different observers on the attenuation of microbic virulence when the micro-organisms were grown under certain physical conditions of temperature, humidity, and illumination. The effect upon the different pathogenetic micro-organisms is particularly noticeable in respect to sunlight. Moist bacilli and spores of anthrax are killed by two hours' direct exposure to the sunlight. Koch states that a few minutes in the sunlight will kill tubercle bacilli, and diffuse sunlight will kill them in from six to seven days. Sawisky found that they gradually lost their virulence in from two and a half to three months in ordinarily lighted dwelling houses. Two hours' insolation is sufficient to kill typhoid bacilli. A few hours' drying will kill the comma bacillus of cholera. None of the pathogenetic parasites multiply under temperatures below 50° F.

Experiments have shown that physical environment can profoundly alter the resistance of the host to infection. Hens will not contract anthrax unless they be first chilled by exposure to the cold. Frogs become susceptible to the disease if kept in an atmosphere of 80° F. or more. Bowditch in this country and Buchanan independently, in England, showed that soil dampness favored the development of tuberculosis. The relation of the ground water and its fluctuations to typhoid has been widely discussed, and the maximum prevalence of the disease after the hot weather of summer has suggested a lowered resistance in the human body. The general prevalence of pneumonia in winter, and its relatively great frequency in climates of high altitudes, have pointed to a meteorological predisposition. As has been mentioned previously, the absolute atmospheric humidity is controlled by the temperature. A cubic foot of air at 32° F. can contain at the most but 2.1 grains of moisture; at 98° F. it can contain 18.7 grains. A cubic foot of air inspired at 32° F. or below, is warmed up in the respiratory passages to about 98°, and is expired saturated with moisture, and it takes from these passages 16.6 grains of water. If this moisture be not supplied rapidly enough by the naso-bronchial mucous membrane, dryness and mechanical irritation result, and this may be the sufficient predisposition for the graver disease, the preparation of the soil for the germ. Excessive evaporation from the respiratory passages is a fact both in cold weather and in elevated regions, and pneumonias are then and there prevalent. Longstaff found that diarrhœal diseases became epidemic in London when the water of the Thames reached 62° F., and Ballard, looking in another direction, found them epidemic when the temperature of the ground four feet below the surface rose for the season to 56° F.

The treatment of disease by climate forms an interesting and important chapter in medical literature. The particular manner and the properties of climate that effect the cures are still subjects of medical polemics. The chief disease that climate is relied upon for curing, to the exclusion of almost all else, is phthisis. That change of climate in this disease is beneficial would be folly to attempt to gainsay. The present consensus of medical opinion leans to the climates of altitude, particularly those above three thousand feet elevation. Altitude, moderate temperatures, clear skies, and well-drained soil appear to be the climatic desiderata for this disease. In this malady the physiological effects of high altitude have usually been considered as the most efficient therapeutic properties of the climate.

The present writer, from a careful consideration of the known physiological actions of the different climatic elements and factors, takes exception to the claims of altitude in this disease. Without entering into any discussion he ventures to state that whatever virtue there is in such widely recognized climates as Colorado, the Engadine Alps, and others as sanitaria for phthisis flows from the absence of clouds and is due to the effects of the intense insolation under low atmospheric temperatures that favor life passed in the direct sunlight rather than in the shade.

The utilization and indications for climate in diseases belong rather to the therapeutics of each disease than to the present article, which is but a brief attempt to define climate and point out the general principles that will indicate what climates are to be expected in given localities, or, a particular kind of climate being given, where it can be most nearly approximated. In climatotherapy, however, one should bear in mind, as a motto, the dictum of Scoresby-Jackson: "If it be a good thing for a sick man to change his residence, it must be a proper thing for him to know what it is that he is avoiding, and what it is that he is to acquire in exchange for it in another place." The what-it-is-that-is-to-be-avoided and the what-acquired must be worked out by the physiologist, pathologist, and the therapeutist much more thoroughly than at present before climato-therapy can become other than empiricism.

Climate and Animals.—Endued with only a limited degree of reasoning ability, but few animals evince any intelligent foresight in providing against future contingencies of heat, cold, famine, or drought. The nearest approach to prevision is exhibited in the migratory and the hibernating habits of some animals, and in the storage of food by a few others. The climatic control of the distribution of animals is perhaps as much one of indirection as of direction. Cats cannot live at an elevation of eleven thousand feet, and all efforts to introduce the Newfoundland dog in India have failed. The polar bear cannot live outside of the isotherm of 32° F., unless surrounded with an artificial reproduction of its native climate. On the other hand, many natives of the tropics find no difficulty in living in the colder temperate zones. Parrots introduced into England flourish in the woods of Norfolk, and that they have not spread over the island is more a matter of food supply than of inimical climatic conditions. The tiger stands the jungle climates of Bengal and the snows of Thibet with equal impunity. The elephant, found now only in the tropics, once roamed over the tablelands of Siberia. The matter of food supply and the ease with which food can be obtained are more influential than the direct physiological effects of the climate itself.

Adaptation to climatic conditions is seen in many animals. The change of color and of thickness of the pelage with the change of seasons is a physiological tribute to climate. The peculiar body formation of many animals is an accommodation to the direct influence of climate. The arboreal animals are unfitted for the treeless prairie. The camel is found in the desert, but it would perish in the forest. Sheep and goats are adapted to the climate of mountains, but not to that of forests. In each and every case we shall find an effort at accommodation in one way or another to climatic environment, and in most of the cases the adaptation is one rather to the food supply, and ultimately to the vegetation of the climate, than to the immediate physiological effects of the meteorological environment.

The key to climatic control of the distribution of animals is in the struggle for food. Many of the extinct animals disappeared not from any secular change of climate, but simply from the advent, often perhaps accidental, of some other form that preyed upon it or its food supply. Goats introduced into the island of St. Helena destroyed a whole flora of trees, and with it doubtless disappeared many if not all of the parasites dependent upon it. Swine introduced in Mauritius destroyed the dodo. The mongoose in Jamaica has completely exterminated the native fauna of this island.

Climate and Vegetation.—The character and distribution of vegetation are both distinctively climatic results. Light, heat, and moisture, in greater or less degrees, are essential to the development of vegetable life. The measures in which these elements are combined determine the general characteristic features of the vegetation. Variations of degree in these characteristics result from the combination of the effects of climate and those of other factors, as the structure and composition of the soil, the effects of animal life, etc. The intense heat and generally abundant moisture of the tropics favor a luxuriant growth in forms that in colder regions are diminutive in size. The vegetation of arid regions is distinct from that of humid countries; and the vegetation of the hot deserts is different from that of the deserts of colder latitudes. Under the equator palms and bananas are the typical forms; then, receding toward the poles, come in succession tree ferns and figs, myrtles and laurels, evergreens, deciduous trees, conifers, lichens and dwarf shrubs, and mosses. If we ascend a high tropical mountain we shall find the same change of vegetational formation.

The following tabular view will present the approximate general distribution of vegetational types with reference to the average temperature under which each best develops.

Zone of—	Average temperature of zone.	Altitude of each under the equator.
Palms Bananas	82°–70° F.	At sea level.
Tree ferns Figs	78 –73	From sea level to 2,000 feet.
Myrtles Laurels	73 –68	From 2,000 to 4,000 feet.
Evergreens	68 –60	From 4,000 to 6,000.
Deciduous Trees	60 –48	From 6,000 to 8,000 feet,
Conifers (pines, etc)	48 –40	From 8,000 to 10,000 feet.
Lichens	40 –32	From 10,000 to 12,000 feet.
Mosses	32° and lower.	From 12,000 to 14,000 feet.

The distribution of the temperature and the rainfall are the most important factors in vegetation. And it is the heat of the summer rather than the cold of winter that determines the limit of vegetation. A broad generalization has been made to the effect that the geographical distribution of animals is dependent upon that of the minimum temperatures of winter, and the geographical distribution of the different varieties of plants is dependent upon the maximum temperatures of summer. Observation of the lowest temperatures at which most plants begin to germinate shows that vital action is not evident till the temperature rises to 43° F. This is the first effective temperature. Plant growth takes place only so long as the temperature is at or above this point, and the amount of growth that actually takes place, other conditions being favorable, is estimated by the product of the number of hours by the number of degrees the temperature is above 42° F. This product is called the accumulated temperature, and represents the total effective temperature for plant development. The higher the temperature, up to a certain optimum, varying for different plants, the greater the rate of growth. The study of plant growth and meteorology is receiving the scientific attention that it so well merits. When more progress has been made scientific phenology will be a most important and valuable assistance to mankind.

W. F. R. Phillips.

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CLIMAX SPRINGS.—Camden County, Missouri.

Post-Office.—Climax. Hotel.

Access.—Viâ Missouri Pacific Railroad to Warsaw, thence 25 miles by stage to springs.

These springs are seven in number, and are located in a rolling, heavily timbered region, with many pleasing landscapes. An analysis of the waters was made in 1882 by Prof. N. W. Wiley, of Purdue University, Indiana, State Chemist.

One United States Gallon Contains:

Solids.	Grains.
Calcium oxide	4.98
Magnesium oxide	1.80
Aluminum oxide (with iron oxide)	5.08
Sulphuric acid	3.60
Carbonic acid	3.92
Sodium	14.00
Potassium	1.20
Iodine Bromine	14.00
Chlorine	20.40
Loss	3.02
Total	72.00

The waters are remarkable for the quantity of iodine and bromine which they contain. They are somewhat similar to the waters of the celebrated Kreutznach Springs, of Prussia, but are far stronger in these ingredients. Such waters are especially adapted for the treatment of chronic syphilitic and scrofulous affections.

The analysis is obviously incomplete, however, and a new examination should be made. We have been unable to obtain a recent report of these springs. The foregoing account is compiled from Walton's work and from the United States Geological Reports.

James K. Crook.

CLOVER, RED.—The flower heads of *Trifolium pratense* L. (fam. *Leguminosæ*). The herbage of most of the two or three hundred species of *Trifolium* is rich in albuminous nutriment, or *legumin*, and red clover is one of the best and the most extensively cultivated of these fodders. During recent years it has come into prominence as an ingredient of a "shotgun" preparation, used as an alterative of which the other ingredients represent the activity. *Henry H. Rusby.*

CLOVER, SWEET. MELILOT.—The dried herb of two species of *Melilotus*, *M. officinalis* Desr. and *M. altissimus* Thuill. (fam. *Leguminosæ*). These are tall, upright, or straggling biennial herbs, with small trifoliolate leaves and axillary spikes of minute clover-like flowers. Both plants are fragrant, having the pleasant odor of Tonka beans, which is also increased by drying. They contain also the same odorous substance found in Tonka beans, *cumarin* (cumaric anhydride), as well as the related substances, *melilotus oil*, *melilotic acid*, and *cumaric acid*.

Melilot is a mild and pleasant aromatic of no special value in medicine, and is fairly obsolete. The infusion was formerly employed to a considerable extent as an eyewash. Dose indefinite. *W. P. Bolles.*

CLOVERDALE LITHIA SPRINGS.—Cumberland County, Penn.

POST-OFFICE.—Newville.

This artesian mineral-water fountain is located 2½ miles northwest of Newville and 5 miles south of the Doubling Gap White Sulphur Springs. It was discovered in 1865 by a party prospecting for oil. The opening bored through the solid rock to a great depth struck this water vein, which, being released from its subterranean confinement, gushed to the surface at the rate of three hundred gallons per hour under the pressure of its own carbonic acid gas. The flow since that time has never diminished, being uniform at all seasons of the year. The water is perfectly clear and entirely free of organic matter, and has a temperature at the spring of 52° F. The following analysis was made in 1889 by Prof. E. T. Fristoe, of the Columbian University, Washington, D. C.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Potassium carbonate	0.20
Lithium carbonate	0.17
Magnesium sulphate	1.60
Magnesium chloride	0.09
Sodium chloride	Trace.
Magnesium bicarbonate	0.42
Calcium bicarbonate	6.67
Iron oxide and alumina	0.75
Silica	0.80
Phosphoric acid	Trace.
Total	10.70
Gases.	Cubic inches.
Carbonic acid	1.070
Oxygen	1.109
Nitrogen	6.013

This water is not heavily impregnated with mineral ingredients, yet when taken in sufficient quantities it exerts an undoubted influence on the physical economy. It has been found to possess antacid, mild aperient, and tonic effects. Its clear and sparkling appearance and freedom from organic impurities qualify it for table and domestic purposes. It is said to have been found fresh and palatable after three years' bottling. The water is used commercially. *James K. Crook.*

CLOVES.—*Caryophyllus*, U. S. P.; *Caryophyllum*, B. P. "The unexpanded flowers of *Eugenia aromatica* Linn." (U. S. P.). "The dried flower buds of *Eugenia caryophyllata* Thumb." (B. P.). This tree, to which each pharmacopœia has given a different name, is a member of the order *Myrtaceæ*, in which are included many aromatic plants such as the allspice, bay, cajuput, and eucalyptus. It is a beautiful, fragrant, evergreen tree, with a fine pyramidal crown thirty or forty feet high, and with bright crimson flowers. The branches are numerous, slender, horizontal, the leaves opposite, lanceolate, pointed, entire, dark green and shining, and covered with glandular dots. Flowers in terminal clusters, articulated. Calyx brilliant crimson, with a long, solid, flattened, cylindrical tube (receptacle of Baillon), in the upper part of which the minute ovary is embedded, and four thick, spreading, triangular lobes. Petals also four, cream-colored, orbicular, arched, in the bud imbricated in a perfect globular head; stamens very numerous, ovary minute, two-celled, many-ovuled, embedded in the fleshy calyx mass; style slender, single. Fruit oval, crowned with the four conniving calyx teeth, one-seeded (the mother cloves of the market). Length of flower about 1.5 cm. (½ in.), of fruit about 2.5 cm. (1 in.).

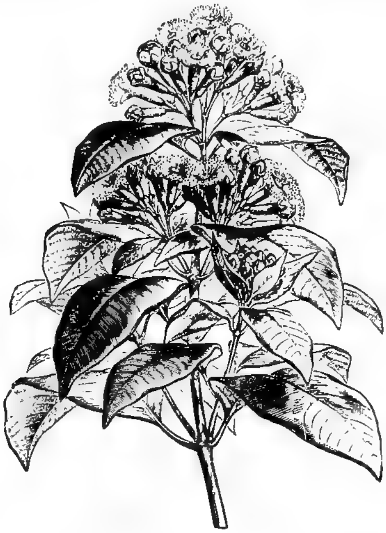

FIG. 1386.—Clove Tree, flowering branch one-third natural size. (Baillon.)

Its orginal habitat was the Molucca and Philippine Islands, but it is now cultivated in the islands of the Indian ocean, Southern India, Africa, the West Indies, and South America. The buds are collected just before the petals expand and the process requires much care and experience. If gathered too soon, the clove is deficient in its aromatic constituents; if too late, the corolla expands when drying. The buds are dried in the sun, and much attention is given to procure the characteristic rich brown color. All parts of the plant are aromatic, and the small branches are often broken into small pieces and colored for the purpose of adulteration. Ground cloves often are made up of a large proportion of the branches and also of the fruit. Another adulteration of ground cloves is the addition of cloves from which the oil has been abstracted. The clove somewhat resembles a nail in shape, its name being derived from the French *clou*. "It is over half an inch long, dark brown, consisting of a sub-cylindrical, solid, and glandular calyx tube, terminated by four teeth, and surmounted by a globular head, formed by four petals, which cover numerous curved stamens and one style. Cloves emit oil when scratched, and have a strong aromatic odor, and a pungent, spicy taste" (U. S. P.). Cloves contain a large percentage of the official oil, which forms as much as one-fifth of its bulk. There are also present tannin, gum, resin, etc.; *caryophyllin*, $C_{20}H_{32}O_2$, which is isomeric with camphor; and *euginin*, none of which are of any therapeutic value. The properties of the clove are contained in the volatile oil. It is obtained by distillation, and is official in the United States Pharmacopœia and British Pharmacopœia. When first procured, the oil is clear and colorless and very fluid; with age and exposure it becomes yellow in color, and ultimately reddish brown. It also becomes thicker. Its specific gravity should be 1.060 to 1.067 at 15° C. It is heavier than water, soluble in equal volumes of alcohol, ether, and acetic acid. It is slightly acid in reaction. Oil of cloves is made up of *eugenol* (*eugenic acid*), $C_{10}H_{12}O_2$, chemically resembling phenol and guiacol, and a terpene, $C_{16}H_{24}$, which is deposited when the oil is kept for a length of time.

Eugenol is formed by a process of oxidation from oil of cloves, and may also be procured from other essential oils, as those of cinnamon, pimento, sassafras. It is an aromatic, colorless, or brownish, oily liquid, insoluble in water, soluble in alcohol, and forms compounds of a definite character with caustic alkalies. It possesses antiseptic properties, and has been recommended as a febrifuge, but is inferior to salicylic acid, quinine, etc. Eugenol, the action of which is somewhat analogous to guaiacol, was brought into prominence by Dr. Koch, who suggested its administration during the tuberculin treatment. The dose is ♏ xlv. during the day, dissolved in spirit and diluted with water. Applied locally it has a mild anæsthetic action.

Two derivatives of eugenol—benzoyl-eugenol and cinnamyl-eugenol—have been introduced and are advocated for the treatment of tuberculous disease. Both of these preparations occur in neutral, acicular crystals, free from color and odor; taste, faintly bitter; slightly soluble in water and freely soluble in alcohol.

The therapeutic action of cloves is due to the volatile oil which they contain, and is that common to all aromatic oils. Externally it is antiseptic, stimulant, and, when freely used, is a counter-irritant. It also is slightly anæsthetic. It is employed locally only as a remedy for rheumatic pains, sciatica, and neuralgias. Its most common use is as an antiseptic and anæsthetic application to carious teeth.

When taken internally it produces a stimulating and antiseptic effect upon the mucous membrane of the stomach and bowels. It also acts as a carminative and antispasmodic, checking fermentation and promoting digestion.

After absorption it produces a general stimulation and is excreted unchanged by the kidneys, liver, and bronchi. Upon these tissues it exercises its antiseptic properties, and it is thought that this is specially directed to the pulmonary tissues. It is this local action upon the lungs which, with its carminative and stimulating effects, has encouraged its employment in tuberculosis.

The oil is usually selected for administration in from one- to five-drop doses. The dose of powdered cloves is said to be from gr. v. to x. An infusion is official in the British Pharmacopœia, 1 part to 40. Oil of cloves is added to several pills, confections, and other preparations for its carminative effects. *Beaumont Small.*

CLUBBED FINGERS; CLUB HAND. See *Hand and Fingers*, etc.

CLUB-FOOT. See *Foot, Deformities of.*

COAGULATION.—Most of the animal proteids can be obtained in solution. Many of these may be coagulated or rendered insoluble by different means. As to the nature of the process, we know very little in addition to the fact that there is a striking difference between the substance formed and the material from which it was produced. The degree of insolubility varies with the different proteids and the means by which coagulation is produced. There is a distinct difference between precipitation and coagulation of proteids. In the former the precipitate may be redissolved again in suitable media, while in the latter the coagulum cannot be dissolved by ordinary media. The difference is well illustrated by the action of alcohol upon proteids. Albumins and globulins are at first precipitated by this reagent—the precipitate may be redissolved; after standing under alcohol for days or weeks they are coagulated and cannot be redissolved. Alcohol also precipitates proteoses and peptones, but does not coagulate them. Ammonium sulphate in saturation will precipitate all proteids except peptones, but does not coagulate any of them.

Coagulation may be brought about: I. By heat or chemical reagents; II. by coagulating ferments or enzymes.

I. Coagulation by Heat.—The coagulation of egg white by boiling is the most familiar example of heat coagulation. The temperature necessary to produce coagulation varies with different proteids. Thus fibrinogen and myosin coagulate at 56° C.; egg albumen and muscle albumen at 73° C.; serum globulin at 75° C. Serum albumin, which was once regarded as a single body, has been found by Halliburton to consist of three different bodies having coagulation points at 73°, 77°, and 84° C. respectively. Not only does the coagulation point vary with different proteids, but even for the same proteid it varies with the salts present and the reaction of the solution. Coagulation occurs much more readily and completely in an acid than in an alkaline or neutral medium.

From the readiness with which albumins and globulins are coagulated by heat they are often called the coagulable proteids.* Vegetable albumins and globulins are coagulated by heat like those of animal origin. Some non-coagulable proteids may be coagulated under certain conditions—*e.g.*, acid and alkali albumins are non-coagulable when in solution, but after precipitation by neutralization they can be coagulated by heat. Proteids coagulated by heat cannot be dissolved by water or saline solution of any strength. Weak acids or alkalies only dissolve them by the aid of heat. The digestive ferments, however, readily act upon them in suitable media.

We know no chemical difference between the coagulum formed by heat and that formed by chemical reagents, but the proteids formed by the coagulating ferments can still be coagulated by heat. Thus myosin of muscle can be extracted by saline solution, but not after it has been boiled. In the digestion of fresh fibrin intermediate products occur which cannot be obtained when it has been boiled. The proteids coagulated by ferments are much more soluble in strong solutions of neutral salts and in weak acids or alkalies than are those coagulated by heat or chemical reagents.

Coagulated proteids behave like native proteids to those tests which can be applied, such as the color tests.

The chemical reagents causing coagulation without definite compounds (such as are formed by salts of the heavy metals) are alcohol, picric acid, tannic acid, and strong mineral acids. Fixation agents such as alcohol, formalin, osmic acid, and mercuric chloride cause coagulation of the proteids of protoplasm in preserving tissues and cause a reticular formation in the cell formerly described as spongioplasm.

II. Coagulation by Ferments.—*A. Coagulation of Blood.*—When blood is shed it soon becomes viscid, and in from three to ten minutes sets in a jelly-like clot or coagulum. The coagulum shrinks and gradually the clear yellowish blood serum separates from the clot. The clot consists of a fibrillar substance, fibrin, entangling the corpuscles in its meshes. Although the clot forms a bulky mass from the large number of corpuscles contained in it, the actual amount of dried fibrin that can be obtained from blood is small, being only from 0.2 to 0.4 per cent. by weight. The corpuscles are not at all necessary for the formation of the clot, as they can be removed in various ways, and coagulation occurs in the fluid of the blood—the plasma—as perfectly as when they are present. The essential part of the clot is the fibrin, a coagulated proteid which is formed when blood or lymph coagulates. The whole problem of coagulation of the blood centres in the formation of fibrin.

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* Some nucleo-proteids are also coagulable by heat.

Fibrin is formed from fibrinogen, a globulin which normally is in solution in blood plasma and has certain chemical peculiarities that distinguish it from other globulins. Fibrinogen is completely used up in the formation of fibrin and none appears in blood serum. The amount of fibrin formed is never quite as great as the amount of fibrinogen acted upon. The fibrinogen is split up by fibrin ferment or thrombin, as it is now generally called, into (1) the coagulated proteid fibrin which represents the larger part, and (2) a small amount of a soluble globulin called fibrin-globulin which remains in solution in blood serum.

The thrombin or fibrin ferment does not normally exist in blood but is formed when it is shed. It results from the interaction of a nucleo-proteid with lime salts, and hence this nucleo-proteid has been called prothrombin. Even the nucleo-proteid or prothrombin does not exist in solution in sufficient quantity in the circulating blood to cause coagulation, but arises from the disintegration of blood platelets and leucocytes (especially the polynuclear leucocytes) when the blood leaves the vessels.

Pekelharing supposes that in the cleavage of fibrinogen the thrombin, being a compound of calcium and nucleo-proteid, yields its calcium to combine with a part of the fibrinogen molecule and form the insoluble fibrin; that the calcium-free thrombin (or prothrombin) then again recombines with free lime salts to hand these over in turn in the formation of more fibrin until all the fibrinogen is used up. This is not the case, for different observers have obtained perfect fibrin by adding a solution of thrombin containing no free lime salts to a solution of fibrinogen from which free lime salts had also been removed in the same way—viz., by the presence of soluble oxalates. Further, Hammarsten has failed to find any more calcium in fibrin than in fibrinogen.

It does not follow from this that lime salts are not necessary for coagulation, but only that they do not combine as Pekelharing at first thought, and that they do not play the same part in coagulation of the blood as they do in the coagulation of milk under the influence of rennet (see the section on "Coagulation of Milk").

On the contrary, lime salts are absolutely necessary for coagulation. If the blood be received directly into a solution of a soluble oxalate (such as potassium or ammonium), the *free* lime salts are removed as the insoluble oxalate of calcium, and coagulation cannot take place, although both fibrinogen and the nucleo-proteid or prothrombin are present. The lime salts seem to interact in some way with prothrombin to form thrombin. After the thrombin is once formed the subsequent addition of a soluble oxalate cannot remove any *combined* calcium.

Although nucleo-proteids extracted from various other tissues of the body (lymph glands, thymus, etc.) influence coagulation, none of them behaves like this one (prothrombin) found in the plasma of shed blood. The latter is not coagulated by the prolonged action of alcohol. The most remarkable difference is that thrombin acts upon blood outside the body, but does not act in the same way upon the circulating blood. On the other hand, other nucleo-proteids, if injected into a vein, rapidly cause extensive intravascular clotting, but do not produce extravascular coagulation. This may be due to differences in the nucleo-proteids or, what seems more probable, in the compounds which they form with lime salts.

If the question is asked, Why does the blood not coagulate in the living vessels? it may be answered that neither thrombin nor prothrombin is present in sufficient quantities in the circulating blood to cause coagulation. But if it is considered how difficult it is to produce intravascular coagulation, or thrombosis, as it is called under these circumstances, by the injection of thrombin or fibrin ferment directly into the vein, it will be seen that this answer is not satisfactory. There is no satisfactory explanation of the failure of blood to coagulate if kept in a portion of a vein carefully removed from the body. Neither can we explain why coagulation occurs in the living body when the endothelial lining of a blood-vessel is altered by disease or injured as by a ligature.

The coagulability of the blood varies considerably, and we are unable to explain the cause of it. Thus it is increased in some acute infections such as diphtheria and pneumonia. As there is an increase of the leucocytes, and also of the number destroyed in these conditions, one might suppose it to be due to an increased amount of nucleo-proteid (prothrombin) in the blood plasma. But the coagulability of the blood is also greatly increased in starvation and rapidly increases during severe hemorrhage. In neither is there any leucocytosis, and we are unable to explain the condition, although it seems to be a wise provision of Nature to prevent death from capillary and venous hemorrhage. On the other hand the coagulability may be greatly diminished and, in the curious disease hæmophilia, almost entirely lost. In many of these cases, according to Wright, there appears to be a deficiency of lime salts, and the internal administration or local application of these will stop the hemorrhage.

The liver seems to be concerned in maintaining the coagulability of the blood in some unknown way. Blood that is kept circulating through the lungs and heart alone soon loses its coagulability. If the portal circulation be cut out of the systemic circulation, the blood also loses its property of coagulating, and agents which alter the coagulability of the blood fail to act under these circumstances.

Certain agents can be introduced into the circulation which will increase, or, on the other hand, lessen or completely destroy the coagulability of the blood. Many ingenious theories have been advanced as to the way in which these agents act, but none of them explains the phenomena satisfactorily. The following conditions hasten coagulation: Agitation of blood by stirring or by passing gases; contact with a rough surface. All of these probably act by hastening the disintegration of the cells liberating nucleo-proteid. The presence of CO_2 is favorable, so that the blood in asphyxia coagulates readily. Heat favors coagulation probably by favoring the formation and action of thrombin or fibrin ferment. It is in this way that sponging with very hot solutions stops hemorrhage.

The following conditions retard coagulation: Receiving blood under oil or in a vessel made perfectly smooth by oil or vaseline. If blood be surrounded by a freezing mixture, the cold may delay and even prevent coagulation. If blood be received into a solution of a soluble oxalate of such strength as to form 0.1 per cent., coagulation is entirely prevented because the lime salts have been removed to form the insoluble calcium oxalate. If blood be received into one-fourth its volume of a saturated solution of magnesium sulphate, coagulation is prevented by the neutral salt—probably by preventing the disintegration of cells, as it can be made to clot by adding thrombin. Extracts of the heads of leeches contain some material which prevents coagulation. Commercial "peptone," which is really a mixture of proteoses, will destroy the coagulability of the blood when introduced into the circulation. No satisfactory explanation can be given of this effect.

Certain substances, as nucleo-proteids, albumoses of snake venom, and certain colloidal proteid-like bodies produced synthetically, can be introduced into the body very gradually, and in small quantities they act so as to lessen or destroy the coagulability of the blood—"negative phase" of coagulation. If, however, these same materials are introduced rapidly and in larger quantities, extensive thrombosis ensues in the heart and large vessels and causes instant death—the "positive phase" of coagulation. Although an enormous amount of work has been performed by investigators to ascertain how these remarkable results are produced, no explanation has been advanced that is without some objection.

B. Coagulation of Milk consists in the formation of a curd or coagulum which separates from the clear milk plasma or whey that still holds the salts and milk sugar in solution. The coagulum is composed of the comparatively insoluble proteid casein and the fats of milk entangled with it. True coagulation of milk is brought about by rennin, an enzyme of the gastric juice. Other curdling agents can also act upon milk, but the changes are not the same. The so-called "spontaneous coagulation" or curdling of milk from souring is not true coagulation, but merely the precipitation of caseinogen. If milk is allowed to stand exposed to the air at a warm temperature, the lactic-acid bacillus soon decomposes the lactose or milk sugar with the formation of lactic acid. When this acid reaches a certain amount, it causes a *precipitate* of caseinogen and fat. True coagulation consists in the conversion of caseinogen into the comparatively insoluble proteid casein, but acids do not produce this change.

The action of rennin in changing the soluble proteid caseinogen into the more insoluble casein is not a simple one. The caseinogen is split up into two parts: the comparatively insoluble casein which forms by far the greater part, and a very small amount of a freely soluble proteid resembling a proteose, called "whey proteid" by Hammarsten. This change is comparable to the change which takes place in fibrinogen in clotting of blood. The fibrin ferment acts upon fibrinogen, splitting it up into the coagulated proteid fibrin and a soluble globulin which passes into solution in the blood serum. The coagulation of milk is further analogous to that of blood in that lime salts are absolutely necessary for the chemical changes, and clotting does not occur when they have been removed by dialysis or the addition of a soluble oxalate. The changes, however, are not identical. In the coagulation of blood the lime salts first combine with a nucleo-proteid to form fibrin ferment, and this then acts upon fibrinogen, splitting it up into a soluble and an insoluble proteid. Rennin first acts upon caseinogen, even in the absence of lime salts, to form a "soluble casein," but no curdling occurs. The enzyme may then be destroyed by boiling, but the addition of a lime salt causes coagulation instantly. The lime salt unites with soluble casein to form insoluble casein.

The caseinogen of human milk is different from that of cow's milk, and forms a flocculent curd with rennet instead of a solid mass.

The curdling ferment of the pancreatic juice produces a peculiar kind of casein, called "pancreatic casein" by Halliburton, which is not the same as that formed by rennet. At the body temperature it forms with cow's milk a granular precipitate and not a coherent clot as rennin does. The removal of lime salts only slightly hinders but does not prevent this curdling. The precipitate differs in its solubilities both from caseinogen and casein, and it can still be converted into true casein by rennin.

Extracts of various tissues, as the testis, muscle, and liver, as well as the juice of certain plants, cause curdling of milk probably in much the same way as does this unnamed ferment of the pancreatic juice.

As stated above, the curdling of milk from souring is not true coagulation. This precipitation of caseinogen, carrying the entangled fats with it, can be brought about by other acids, *e.g.*, by the cautious addition of acetic acid. The precipitate resulting from the addition of an acid is usually flocculent and contains less lime than that formed by rennin. It can form even in the absence of lime salts, and is more easily redissolved than is the curd containing true casein. Moreover, it can be dissolved and recurdled by rennin, *i.e.*, converted into true casein. Although true casein can be dissolved, it cannot be recurdled by rennin. This is the most striking difference between caseinogen and casein.

Although the lactic-acid bacillus does not cause true coagulation in the ordinary souring of milk, some bacteria, either by their life activity or by some product of their metabolism, produce a coagulum which appears to be a true clot. This fact is utilized by bacteriologists to distinguish between different kinds of bacteria, but probably occurs only under ordinary conditions in those very exceptional instances when a ropy or stringy clot forms in milk.

C. Coagulation of Muscle.—Rigor mortis, or the rigidity of death, is due to a coagulation of muscle proteids. If the muscles of cold- or warm-blooded animals be freed from blood and mixed with ice and salt, or extracted with a rather strong solution of neutral salt, a clear muscle plasma containing most of the proteids of muscle can be obtained. By raising the temperature in the one case or diluting with water in the other, a coagulum consisting of myosin is formed from the proteids that were in solution and separates from a clear serum. Myosinogen, a globulin-like body which constitutes about eighty per cent. of the proteids of muscle plasma, is converted into myosin. Paramyosinogen, another globulin which is only one-fourth as abundant as myosinogen, is also contained in the clot. Small amounts of other proteids (myoglobulin and myo-albumin) remain in solution in muscle serum. The formation of myosin results from the action of a myosin ferment upon myosinogen. This enzyme can be extracted from muscle in the same way as fibrin ferment is obtained from blood serum. The two, however, are not identical, for fibrin ferment cannot coagulate myosinogen, neither can myosin ferment coagulate fibrinogen. Free lime salts do not appear to be necessary for the formation of myosin. Myosin is much more soluble than other coagulated proteids resulting from the action of enzymes, and is often classed with globulins because of the ease with which it can be dissolved by saline solutions. Further, the difference between myosin and the mother substance from which it is formed (myosinogen) is not so great as in the other cases. In the coagulation of muscle, CO_2 and lactic acid are formed, probably from the chemical changes taking place in the proteids.

The appearance of rigor mortis in the muscles is due to these same chemical changes that have been described in muscle plasma. The rigor often disappears before putrefactive changes appear. A proteolytic ferment has been found in dead muscles, and this is probably greatly aided by the lactic acid in causing the myosin to disappear.

The presence of acids, stopping the blood supply, or heating the muscle will cause coagulation that is often called "acid-" or "heat-rigor." In the cold-blooded frog 40° C., in the mammal a temperature of 48° to 50° C., will cause heat rigor. This is probably only the premature appearance of rigor mortis in the dying muscle. It is entirely different from heat coagulation, as the myosin can be dissolved by solutions of neutral salts, while proteids coagulated by heat cannot. Further, the other chemical changes are the same as in rigor mortis, and the myosin formed is still coagulable by heat.

William S. Carter.

COAGULATION NECROSIS. See *Necrosis.*

COAL GAS. See *Carbon, etc.*

COCA.—*Erythroxylon.* "The leaves of *Erythroxylon Coca* Lamarck" (U. S. P.).

(Owing to their important bearing upon the value and uses of this drug, we find it necessary to discuss in some detail portions of its history which in the case of most drugs are practically unimportant. The several departments are indicated by small capital side-headings, so that the reader can readily refer to any desired portion of the subject.)

Definition.—The limitations of the official definition are by no means clear, though highly important. The different varieties of the coca leaf vary in qualitative action to a degree not recognized in our best text-books and appreciated by very few practitioners. If the one plant is to be regarded as a mere form of the other, then the definition includes two drugs, sufficiently distinct to receive recognition under two titles, as is certainly true of the British Pharmacopœia definition, which says: "The leaves of *Erythroxylon Coca* Lam. and its varieties." If, on the other hand, each is to be regarded as a distinct species, then that leaf which appears to be of the higher medicinal value is excluded from the Pharmacopœia in the interest of one yielding a larger percentage of crystallizable cocaine. There are various good reasons for taking the latter view, so that in this article Coca (U. S. P.) will be regarded as only that variety known as the "Huanuco," or "Bolivian," or "Large Brown" leaf (Fig. 1387). Of this there are noticeable forms or grades, but these may be regarded as differing in degree rather than in kind. Thus, the best Bolivian (Yungas) leaf is rather smaller than the same grown in Peru. The term "Peruvian" is too indefinite for use, as it may reasonably be applied to either this or the Truxillo variety. When we have quite finished with the article thus defined, attention will be given to the Truxillo variety and to other species of the genus.

ORIGIN.—There is no reasonable doubt that the species originated upon the eastern slope of the South American Andes, probably in Peru. Since it was cultivated in prehistoric times, there is no way of certainly ascertaining whether it was wild in its present form or whether the latter is a product of development by cultivation from some other wild form. The latter is probably true, because in the wild (escaped) state it shows a strong and rapid tendency to lose its characteristics. It is impossible to say of any of the wild plants collected by the writer and others that they are not escapes from cultivation, many known to be such having been encountered. Lastly, it is not known whether the ancestral form is one of those still in existence in a wild state.

HISTORY.—The coca plant was under cultivation at the time of the discovery, and no clew to its introduction to cultivation could then be, or has since been, obtained. It occupied an important place in the religious and mythological history of the people. This is of interest here only because of the unquestionable fact that such esteem was the result of an appreciation of its useful properties, rather than, upon the contrary, and as for centuries believed, the superstitious reason for its being used. We may therefore dismiss its mythical history (see "Coca at Home and Abroad," *Ther. Gaz.*, March and May, 1888, also p. 14, 1886) as being here unimportant, and consider its physiological and therapeutical history. Its expectorant, sialagogue, stomachic, carminative, emmenagogue, and aphrodisiac properties are among the minor ones for which it was and is used by the natives. As a stomachic, it is recognized that its use before meals detracts from the appetite, but that its use thereafter relieves any discomfort resulting from excess, while not appreciably inhibiting digestion. In fact, its general repute is that of aiding digestion. The more important objects of its use are as a limited cerebral stimulant, an anæsthetic, a very peculiar muscular stimulant, and an ordinary masticatory. As a cerebral stimulant it filled the place of coffee. It was used before the latter was introduced, and after that event it continued to be used by the natives, while the much more expensive coffee was used by the foreign element. In this direction its characteristics were to promote cheerful and hopeful views and sentiments, without excitability, but rather with increased calm. As an anæsthetic, its use was a general more than a local one, though it was locally applied to ease pain, and its carminative and stomachic uses were clearly of this nature. The object of overcoming the pains of hunger and of fatigue were pre-eminent, while that of securing relief from pain by a mild general anæsthetic, in spite of increased wakefulness, was general.

The term "muscular stimulant" is not accurate, but is used for want of a better. More lengthily stated, the plant was used to enable man to perform more labor with less fatigue and with less nutrition. Without regard to the facts of the case, this was the belief of its users. In consequence of these effects, bodily or mental, they performed almost incredible physical tasks, long-continued, upon a food supply, the scantiness of which is equally astonishing, and with results not injurious beyond causing temporary inconvenience. The special adverse conditions to be met in these efforts were the continued scaling of steep and high acclivities, with little food and with a very scanty supply of oxygen, and under the necessity of either attaining a high speed or transporting heavy loads.

The above statements, in substance, were among the earliest historical records promulgated concerning its use by the people of the countries concerned, and they have been repeated, with assurance, by all subsequent investigating travellers. Many of these travellers went to extraordinary lengths to test their accuracy, and always with affirmative results. Travellers and foreign residents verified them by personal experience and very frequently relied upon them for personal help. These assertions were met abroad by religious opposition because of the heathen relations of the coca customs, by very great professional conservatism, and, lastly, by discredit because the leaves, exported for use, largely failed, in the condition in which they were received, to verify them. All the present important uses of the drug in its own form, or in that of cocaine, cannot be said to cover the same ground involved by the native uses of coca leaves. There appears to be but one rational explanation of this broad discrepancy, namely, changes in properties which the leaves undergo after being dried. This view has been verified by the writer by numerous assays of the leaves soon after collection, compared with others made later. Preparations made upon the spot have also been found, by extended trial, to act more like the leaves as chewed by the natives than like preparations made from the exported leaves.

The details of the method of use have been so often published that any account of them appears scarcely necessary in this article. The use of *Llipta*, or ashes, with the bolus is to be regarded partly like that of condiments, especially of salt as such, without food. At the same time, the suggestion made by Holmes that the effect of this alkali is to decompose the alkaloid, cocaine, developing new constituents which exert the desired physiological action, is full of food for thought and experiment.

CULTIVATION AND PRODUCTION.—The product in use proceeds wholly from cultivated plants. Leaves from wild plants are unfit for use. Its cultivation is generally like that of the coffee and tea shrubs. Details will be found in the article last cited. Cultivation is very extensive in Bolivia, whence large quantities are exported to Peru for native use, in addition to the large quantities there produced. The annual consumption is to be stated in tens of millions of pounds. It is comparatively little grown outside of the two countries named, the product of Ecuador, Colombia, Venezuela, Brazil, India, Java, Mexico and other countries being chiefly of the other kinds. There is no point in the United States where the climate would admit of its being grown satisfactorily, though it would probably do well in the mountains near Santiago de Cuba.

The Coca Plant.—The shrub grows from five to eight feet high and is widely branched. The trunk may ultimately attain a thickness of four or five inches, and it, with the larger branches, soon becomes shaggy with gray lichens. The twigs soon become scaly with the closely set, stiff, almost spinose persistent stipules, and are densely leafy toward their ends. The small white or cream-colored flowers grow in little fascicles, close against the bark, on the older and leafless parts of the twigs. They are followed by an investment of ovoid, slightly inequilateral, smooth drupes, which become about a fourth of an inch long and of a deep-red color. The first crop of leaves can be gathered at about two and a half years from seed, and the shrubs bear well for twenty or thirty, or even forty, years. There are no definite months for picking, the condition of the leaves determining the time. Their development at the tip of the twig is continuous, and if allowed, they would as continuously fall off below, but they are picked just in time to avoid loss from this cause. The shrub yields two or three, or sometimes even four, crops in the twelve months. They are picked by hand and immediately dried in the sun upon smooth floors of hard clay, or preferably of flat stone. As the upper layers dry the lower must be continually stirred up. Not even the slightest amount of rain must be allowed to fall upon them. Hence men stand always ready with huge brush brooms, and upon the slightest indication of rain sweep them through the immense doors of the buidings which surround the drying-floor. A few hours of hot sun is sufficient to dry them, but they must be kept in the houses for two or three days to undergo a slight sweating process. When this supplementary moisture has dried, they are pressed very tightly into small bales, called *cestos*, and are ready for marketing. The tight pressure is as much to exclude the moist atmosphere as to secure convenience. For transportation across the mountains and export they are encased in oil cloth or rawhide. Upon being opened the few outer layers may be found discolored, but if properly dried and packed it is rare that the remainder undergoes any conspicuous change. Yet a slow deterioration commences at once after drying. No matter how carefully they are kept, the chewers prefer them in proportion to their freshness. After being kept for a very few months they will scarcely be accepted for native use, and these leaves, which the natives would reject, are the only ones which are ever used by us for medicinal purposes. The chemical nature of this change has never been determined, though the writer has demonstrated that it is due to only a slight extent to the loss of cocaine, which is clearly not the constituent which the native chewers find most efficacious, a fact to be borne in mind in connection with their use of alkali, as referred to above. Neither is it true, as has often been suggested, that this native preference is due to differences of savor merely.

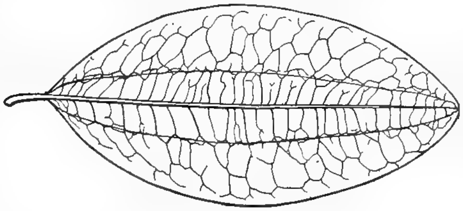

FIG. 1387.—Huanuco or Bolivian Coca. (*E. Coca* Lam.) Natural size.

Aside from the method of chewing, which is despised by the better classes, large quantities of the leaves are prepared in the form of a sort of fluid extract or cordial for use as a liquor or *pousse café*.

Coca paralysis or coca mania, which has frequently been discussed in a somewhat sensational way in the medical press, and which has been compared with cocainism, is so rare, at least among the Bolivians, as to be almost a fiction. The writer was never able to find a case or any authenticated account of one. Nevertheless it is not unlikely that such do occur.

DESCRIPTION OF DRUG.—The leaves occur in a yellowish-brown to brown mass, a distinct green color being rare, and even a distinct green tinge to the brown being oftener wanting than present. Much of the quality is to be determined by the color characteristics. A very young, and therefore inferior leaf, is more apt to retain the green color. A badly cured or preserved or very stale leaf will be of a dark brown. If only stale, this brown will be uniform and dull; if badly cured, it will be smudgy and patchy and of a stained appearance. The perfect leaf will be of a rich, light, clear brown, with more or less of golden or greenish tinge, never bright green, and with a slight lustre. They are mostly flat and unbroken in the best preserved samples. They have a very short, stout petiole. The blade is from 2.5 to 7.5 cm. (1 to 3 in.) in length, and a very little more or less than half as broad. It is oval in outline, a very slight point at the apex and a very short abruptly narrowed basal portion, the length of which is not more than one-twelfth of the entire blade. Except for this portion and the slight tip, the outline is an almost perfect ellipse. The margin is quite entire, the surface smooth, the body thickish, the consistence somewhat tough and slightly leathery. The midrib is very prominent below, traversed by a narrow ridge above. The venation markings are rather obscure on both surfaces, especially above. Upon the lower surfaces two characteristic lines are prominent, known as the "lateral lines." They run at a little more than one-third of the distance from the midrib to the margin, and terminate at both ends, not in the midrib, but in the margin, at a slight distance from it. They are not veins, but consist chiefly of collenchyma cells, and are to strengthen the edges of the folds, in the bud. The surface enclosed by them is of a lighter shade than that outside, and is known as the "areola." The more highly cultivated and finer and richer the leaf, the more conspicuous are these lines. As the plant escapes and retrogrades in the wild state, these lines appear less conspicuously in the dried leaf, which becomes thicker, browner, more veiny and rougher of surface. The foregoing is a description of the typical leaf, as grown in the Andes and some other parts; it varies with the narrowed basal portion longer, but always much less than half the length of the leaf, and the leaf never narrower than obovate. It also varies to paler, but is never of a pale senna-green color, like the next variety. The apex is often very slightly retuse, and the midrib produced into a slight apiculation or mucronation. The faint odor has been denominated "tea-like," but it is characteristic of coca. The taste is slightly bitter and barely aromatic. The bitter taste is greater in poorly cultivated and in wild or shade-grown leaves. A little while after chewing anæsthesia of the tongue and lips occurs. Experience can enable one to estimate almost exactly the percentage of cocaine by the degree of this effect.

Some other leaves are occasionally chewed by the natives when coca is not obtainable, purely as a masticatory. One of these is apparently a Mimosea, and is called "Chiuchi-coca." None of these is observed in our drug, which is not likely to be adulterated nor substituted by anything except another variety of coca.

COMPOSITION.—The alkaloid *cocaine* is, in professional medicine, the important constituent, and exists to the extent of one-half to nine-tenths of one per cent. This alkaloid is considered in a separate article. Since it is a *methyl-benzoic acid* compound of the alkaloid *ecgonine*, it is not surprising that the latter alkaloid should be encountered in the drug, both free and in combination with various other substances. Neither the constancy nor the percentage of these, nor the resulting modification of the drug's action, has been investigated or much considered. With these alkaloids, there is a little tannin and wax and a very slight amount of an aromatic principle.

ACTION.—So far as medicinal practice and literature are concerned, the action of cocaine is that of coca, and will be considered under the title of *Cocaine*.

That the two are the same in action is assuredly not true, but the differences between them and the action of the other alkaloids are subjects which have not been suitably investigated, the assumption generally prevailing that they are practically the same. No differences can be expected between cocaine and coca as it reaches us, with cocaine as the chief constituent, which can be compared with those between the alkaloid and the leaves immediately after being collected and dried, for careful drying effects scarcely any change in their composition or activity. In spite of this fact it is unfortunate that the action of our leaf preparations should not have received more study. The only official preparation is the fluid extract, of which the dose is 2 to 4 c.c. (fl. ʒ ss. to i.). A properly made wine of coca should contain about fifteen per cent. of the drug, the dose being 8 to 16 c.c. (fl. ʒ ij. to iv.).

Other Varieties and Species.—The genus *Erythroxylon* is one of two in the family *Erythroxylaceæ*, and it contains about one hundred and forty species, for which more than one hundred and seventy names have been proposed. About one-sixth of the species are foreign, the others natives of tropical American countries. Cocaine, or at least some principle having slight locally anæsthetic properties, pertains to several species, but in only three, or only one with its two varieties, if that view be taken, are they of practical importance. Of these the principal one has been considered above. That next in importance is *E. Truxillense* Rusby (*Druggists' Circular*, 1900, p. 223), or the Truxillo, or "Small Green" leaf. It was called *E. Coca Spruceanum* by Burck, but is a distinct species, and there is already an *E. Spruceanum* Peyr. This is the leaf chiefly cultivated in Northern Peru, Ecuador, Colombia, Mexico, and Brazil. It is not the one commonly spoken of in English journals as the Truxillo leaf. According to Burck, it is also the leaf cultivated in Java and is sometimes written of as the "Java" leaf. Its most distinctive characters are its uniformly small size, pale, senna-green color, thin and brittle texture, and tapering base. It varies between obovate and oblanceolate, the lower half tapering gradually, and is about two-thirds the size of the Huanuco variety. The apex may contract abruptly into a short point, or be slightly emarginate, then apiculate. It is exceedingly thin and brittle, and occurs much broken. Its color and general appearance at a distance are those of India senna. Most of the leaves, in the dry state, are wanting in the lateral lines, and when these are present they are quite indistinct. The mode of cultivation and packing of this variety are about the same as of the other, but it does not bring so high a price. The published statements as to its composition are very contradictory. Its yield of total alkaloid has been placed as high as 2.25 per cent., but this estimate is doubtless erroneous. A more trustworthy assay makes it about one per cent., or a little higher than that of the last. This alkaloid, however, differs greatly in kind from that of the official leaf. Instead of cocaine it consists, to a very considerable extent, of cinnamyl compounds of ecgonine. It yields a much larger percentage of truxilline (isatropylcocaine) than either of the others, with benzoyl-pseudotropeine. Of these, the former is believed to be poisonous, while the latter is less poisonous and acts very much like cocaine. Certainly, manufacturers find it impossible to produce from it an equal quantity of cocaine. This, however, affects the manufacturer alone, for it by no means follows that it is inferior for medicinal use. In fact, the use of the fluid extract prepared from this variety has been found by many physicians to produce better results than the use of that from the other variety. This, it may be remarked, is quite in keeping with several other indications already mentioned, that much of the physiological action of coca is not referable to its cocaine. It appears to be the benzoyl-ecgonine which produces the stimulant effects, while lacking the anæsthetic properties. It would seem to the writer that the idea of substituting this variety for that now official, and of allowing the latter to be represented by cocaine only, is worthy of the most careful consideration.

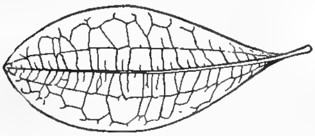

FIG. 1388.—Truxillo Coca. (*E. Truxillense* Rusby.) Natural size.

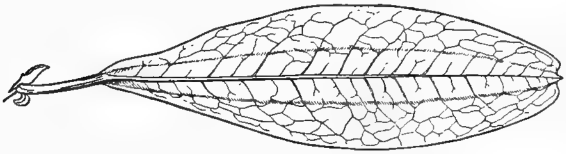

FIG. 1389.—*E. Carthagenense* Jacq. (?)

There is a third variety of the coca leaf, known in English journals as the Truxillo leaf, but never seen in the New York market, where the Truxillo leaf is an important article of commerce. It has been called by Morris "E. Coca Nova-granatense," but there is little doubt that it is one of the first described species of Erythroxylon, namely, *E. Carthagenense* Jacq. It appears to be native in Colombia, and largely cultivated in the British provinces, whither all the stock was sent from a single plant cultivated in the Kew Botanical Gardens. The leaves (Fig. 1389) are about two, or even three inches long by one-third as broad, oblanceolate, with a very long tapering base and a rounded, mostly emarginate, then mucronate summit. They are pale and thin, and the lateral lines and areola are very well marked. Their composition is very similar to that of the Truxillo leaves, though it is said that the isotropyl-cocaine is wanting, or present in slight amount. There appears so far to be no good reason why they should not rank with the Truxillo leaves as a medicinal agent, though much fuller information concerning them is required.

Henry H. Rusby.

COCAINE.—(*Methyl-benzoyl-ecgonine*) $C_6H_7(CH_3)N,CH(O,CO,C_6H_5)(CH_2,CO,OCH_3)$.* Cocaine itself is not official in the United States, but its hydrochloride is, as "the hydrochlorate of an alkaloid obtained from coca." Quite a number of other salts of it are in the market, but this is the one most used. As it is therapeutically the equivalent of the alkaloid, except as to its solubility and slightly lower strength, we may discuss its properties as those of the alkaloid itself. The origin of cocaine is sufficiently explained in the preceding article on *Coca*. It was first isolated by Gardeka in 1855 and by him named *Erythroxyline*. Niemann, who renamed it cocaine, gave much fuller information concerning it. It was many years after its discovery before its physiological action was thoroughly investigated, although its benumbing power and its action in dilating the pupil were early made known. About the year 1880 many important reports concerning it began to appear, and its remarkable uses in ophthalmology began, in 1884, to be developed. The first productions were extremely expensive, selling as high as $3 per grain, with a steady reduction to a little more than one cent per grain five years later. Those very high prices were due merely to rarity of manufacture. The subsequent lower, but still very high prices were due to the presence in Europe and America of only accidental lots of leaves at a time when a heavy demand arose. After the demand for the leaves began to be fully met, prices which would now be considered very high were still maintained, in consequence of manufacturing expenses which have since been greatly reduced. Coincident with these high expenses of manufacturing, the processes of purification were imperfect, and led to many serious accidents in the application of the drug to the eye, and to misinterpretations of its normal action. At the present time, manufacturing processes may be considered to have been about perfected, as to both quality and economics, and the action of the drug is as well known as that of almost any other.

In spite of the very extensive use of eucaine and orthoform, which act similarly, and in some respects preferably, to cocaine, the consumption of the latter is enormous, reaching in the United States probably not far from 150,000 ounces annually and is steadily increasing. Various natural products, such as *erythrophleine*, have been proposed as substitutes, but their action is far from being as satisfactory. Originally, all cocaine was extracted from the leaves in this country and in Europe, but since then economies in transportation and the avoidance of damage to the leaves in transit have led to its extraction in an impure state at the points of production in Peru and Bolivia, and its subsequent purification in Europe, our tariff prohibiting its profitable importation into this country for that purpose. The following method of manufacture was supplied by Dr. Squibb for the last edition of this work:

The ground coca leaves are moistened with a solution of carbonate of sodium, and the alkaloid directly extracted from them by percolating with kerosene. From this kerosene solution the alkaloid is washed out by means of weak sulphuric acid, and for purposes of purifying precipitated again by carbonate of sodium in the presence of a small portion of kerosene to dissolve it again. This process of precipitating and redissolving is repeated several times. At last the crystals of the crude alkaloid are dissolved in dilute acid and freed from kerosene by means of ether; then the alkaloid is precipitated again in the presence of ether, the clear ethereal solution (of the alkaloid hydrate) shaken out with hydrochloric acid, and the solution of the hydrochlorate evaporated to dryness.

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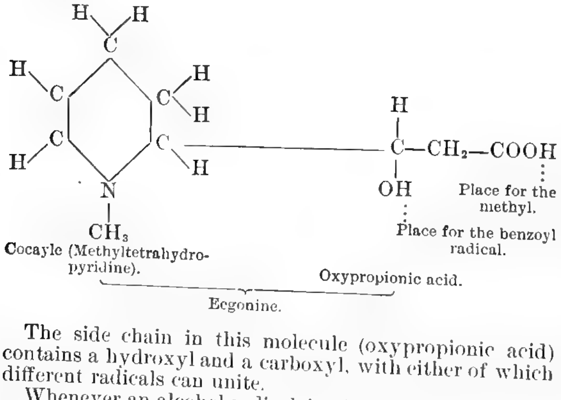
* The writer of this article desires to acknowledge his indebtedness to Prof. Henry H. Rusby, of this city, for valuable assistance rendered in the revision of the text.

Much discussion has taken place as to the accuracy of the following (*Maclagan's*) test for the purity of cocaine, as a result of which it seems to have been generally accepted by our best authorities. It consists in dissolving one grain hydrochlorate of cocaine in two ounces distilled water and adding one to two drops of ammonia solution. If free from amorphous cocaine, on stirring the ammoniated solution for a few seconds cocaine hydrate separates out in crystalline form and falls to the bottom, leaving the supernatant solution clear and free from opalescence. If it is at all milky, the presence of amorphous cocaine is indicated.

Gartier's test is as follows: When a solution of 2 cgm. to 0.5 gm. of hydrochlorate of cocaine is mixed with one drop of a two-per-cent. solution of permanganate of potassium, the resulting fluid must assume a red color and remain transparent. On a subsequent addition, drop by drop, of the permanganate solution, there must appear a red precipitate consisting of permanganate of cocaine, which becomes brown only after heating and that without evolving an odor of bitter almonds. When the addition of one drop of the permanganate solution brings about a brown discoloration or brown precipitate, or when on heating the mixture there appears an odor of bitter almonds, the preparation is impure and unfit for use.

CHEMICAL CONSTITUTION.—Cocaine, if heated with hydrochloric acid, splits into benzoic acid, methyl alcohol, and a new alkaloid, ecgonine ($C_9H_{15}NO_3$), of not well-pronounced physiological action. As was to be expected, there is an intimate connection between the constitution of the cocaine molecule and its physiological action. There exists quite a series of bodies similarly constituted, with analogous physiological action, facts that have been studied by Ehrlich (*Deutsche med. Wochenschr.*, 1891, No. 32, p. 717) and E. Poulsson ("Beiträge zur Kenntniss der pharmakologischen Gruppe des Cocain," *Arch. f. experimentelle Pathologie u. Pharmakologie*, vol. xxvii., p. 301). In ecgonine a group called cocayle, $(Ch_3)NC_5H_7$, whose constitution is methyltetrahydropyridine, is combined with the radical of oxypropionic acid, thus:


Place for the methyl.
Place for the benzoyl radical.
Cocayle (Methyltetrahydropyridine).
Oxypropionic acid.
Ecgonine.

The side chain in this molecule (oxypropionic acid) contains a hydroxyl and a carboxyl, with either of which different radicals can unite.

Whenever an alcohol radical is affixed to the carboxyl group, and at the same time an acid radical enters the other replaceable hydroxyl group, the resulting body in chemical and physiological action closely resembles cocaine. In this latter methyl (CH_3) and benzoyl ($C_6H_5CO_2$) are the two radicals entering into the oxypropionic rest. The coca leaves contain various cocaines with radicals other than those given above, and by chemical synthesis a great number of them have been formed. So the methyl of the ordinary cocaine has been replaced by ethyl, giving rise to coca ethyl, and the benzoyl has been substituted by the radicals of baldrian-, cinnamon-, or phenyl-acetic acid, thus leading to another series of homologous alkaloids. But this does not exhaust the possibilities for the formation of bodies similarly constituted and with similar physiological action. The radical of the oxypropionic acid contained in the ecgonine molecule can be replaced by other acid radicals, which of course must contain one carboxyl and one hydroxyl group. In fact, by oxidizing ecgonin, Einhorn has succeeded in composing a body which contains oxyacetic acid instead of oxypropionic acid. By introducing the benzoyl and the ethyl in this new combination a body is obtained which is isomeric with cocaine and possesses highly anæsthetic qualities, at the same time surpassing cocaine in poisonous effects, as Ehrlich has found. Experiments with a number of these cocaines and their components have shown that the alcohol radical above mentioned is essential for the anæsthetic effect, and that with its removal from the cocaine molecule the anæsthetizing and poisonous properties disappear (Poulsson, *loc. cit.*).

That the local anæmia observed upon local application cannot be the cause of the anæsthesia, as several authors have asserted, must be apparent to everybody, who, applying it to the eye, notices that the anæsthesia of the cornea precedes the anæmia of the conjunctiva. Several facts, as for instance the slight cloudiness and the dotted erosions of the corneal epithelium after repeated applications of cocaine, pointed to this drug being a general protoplasma poison, first stimulating and then mortifying it. The writer, who in his first experiments noticed the haziness of the corneal epithelium, was inclined to consider it due to evaporation, in consequence of the arrested secretion of tears and diminished winking of the lids, brought on by the local anæsthesia. When, with the increasing general use of cocaine as an anæsthetic, reports began to come in about opacities of the cornea occurring after operations in which cocaine and simultaneously solutions of corrosive sublimate had been used (Herschel, Bunge), the writer set out to determine this question by experiment. Wuerdinger, of Munich ("Experimentelle und anatomische Untersuchungen über die Wirkung des Cocain auf die Cornea," *Klinische Monatshefte für Augenheilkunde*, 1886), had come by his experiments and his pathological researches to the conclusion that the haze was due to dryness of the cornea. In 1886, while in Utrecht, the writer conducted a series of experiments on rabbits, the results of which, however, were never published. Cocaine was instilled into the rabbit's eye and the lids carefully closed over it with an artery forceps, while the other eye was kept open by means of an eye speculum. The eye that had been kept open (and into which no cocaine had been instilled) showed drying and loss of epithelium after several minutes, while the cocainized eye showed that by carefully protecting it, the hazy appearance and loss of epithelium in it had been reduced to a minimum. Evidently, therefore, evaporation was a factor to be taken into account. [Other experiments established the evidence that the corneal epithelium is especially prone, when cocainized, to become hazy when the eye is washed with solutions of corrosive sublimate (of the same concentration as that commonly used in eye surgery, 1 to 4,000–5,000).] But however careful or however often the experiment was made, repeated instillations of cocaine would always produce some haziness and some dotted defects of the epithelium—a condition, though, that would return to the normal within a few hours. It was nearly certain, therefore, that cocaine, as such, affects epithelial cells in their vitality. This probability became stronger yet by comparison with the action of erythrophleine, an alkaloid extracted from the bark of *Erythrophlœum Guineense*. This alkaloid, like a number of others, has very strong anæsthetic properties, even stronger than cocaine. The irritation preceding the anæsthesia is much more marked and of longer duration than in the case of cocaine, and correspondingly the inroad upon the vitality of epithelium and corneal tissue is a more vehement one. Two drops of a one-eighth-per-cent. solution instilled into the writer's eye (Koller, *Wiener medicinische Wochenschrift*, 1888, No. 6, and Chicago *Medical Journal and Examiner*, April of the same year) proved to be sufficient to set up an irritation of thirty-five to forty minutes' duration, and to produce a distinctly visible opacity of the cornea which took two days to disappear entirely. (This property, together with the highly poisonous action of the drug, has prevented the practical use of it recommended by Lewin.*) The initial irritation, the ensuing anæsthesia, and the simultaneous clouding of the epithelium are all proportionate in the action of the two drugs, and strongly point toward an intimate, or rather a causal, connection.

Extensive researches on the action of cocaine upon the vital manifestations of various kinds of cell elements and low animals, instituted by Albertoni (Pietro Albertoni, "Azione della cocaina sulla contractilita del Protoplasma," *Ann. d. Chim.*, 1890, p. 305), have shown that cocaine is a protoplasma poison. According to its concentration and the duration of its action, it stimulates or paralyzes the protoplasma in its vital functions. For instance, a 0.25-per-cent. solution applied to the palate of a frog stimulates the activity of the ciliated epithelium, so that particles of coal-dust are moved along with four times the ordinary velocity, while two-per-cent. solutions slacken the velocity to the fourth or sixth part of the normal. Grubs of butterflies and amœbæ in a physiological solution of NaCl stop their movements upon the addition of one-half to two per-cent. cocaine, and so do the large white blood cells of astacus. Spermatozoids and other ciliated cells stop their movements in strong solutions of cocaine or when subjected to the protracted action of weaker ones. The mucous glands in the membrana nictitans of frogs lose their ability to respond to electrical stimulation. The effects of the electrical current observed in pieces of muscle and nerve soon disappear under the influence of cocaine. So the experiments of Albertoni have established beyond a doubt the view, which was the most reasonable and probable one, that the local anæsthesia is the effect of a paralyzing influence upon the ends of the sensitive nerves. A pathological supplement to this theory is the fact that nerve fibres in five-per-cent. solution of cocaine look less bright than they do in 0.6 per cent. sodium chloride solution (Alms, "Wirkung des Cocain auf die peripheren Nerven," Du Bois Reymond's *Archiv für Physiologie*, 1886). A peculiarly characteristic and deleterious effect is exercised by cocaine upon the cells of the liver. The livers of mice, which Ehrlich ("Studien in der Cocainreihe," *Deutsche med. Wochenschr.*, No. 32, p. 717) had fed with cocaine (0.01 to 0.02 to the "cake," Prince Albert cracker), and which had perished within a few days under this diet, showed considerable increase in volume, and their macroscopic appearance reminded one of the stuffed-goose liver. The microscopical examination showed vacuolar degeneration of the cells; the latter were enlarged, containing many vacuoles, and very small remains of protoplasma about the nucleus. No glycogen was to be found in the cells, nor in fact in the whole liver. The hepatic connective tissue showed fatty degeneration and "Coagulationsnekrose"; the stellated cells and the endothelia of the blood-vessels also showed fatty degeneration.

Action upon Nerve Tissue.—The action of cocaine upon nerve tissue, therefore, cannot be considered as being of a specific kind, but is rather identical with the general action of this drug upon protoplasma, the only difference being that the nerve tissue responds more readily and more effectively to outside influences. In accordance with this view one would expect that all nerve tissue would be similarly affected by it- although the action upon the ends of the sensitive nerves is most marked and constitutes the most striking property of cocaine and its main claim as a valuable therapeutic agent.

In order to test the action of cocaine on other than peripheral sensory nerves, the writer devised a series of experiments, with the purpose of deciding the question whether the terminal apparatus of the higher senses could also be paralyzed by cocaine. The field of experiment selected was the retina. In two cases in which an enucleation of the eyeball had to be performed, perception and projection of light being still present, cocaine was injected into the orbits by means of a hypodermic syringe, as near to the eyeball as possible. In one of these cases it was apparent that the perception of light was affected in that part of the field of vision which corresponded to the place of injection. Continued injection in other places around the eyeball blinded other corresponding parts of the field, until after some time nearly all perception of light was lost. The other case did not give any satisfactory result, on account of which these experiments were not published. (The experiments were made in Professor Snellen's Eye Clinic, in Utrecht, in 1887.) Experiments on dogs, undertaken in common with Dr. H. Zwaardemaker, in Utrecht, failed, on account of the toxic effect of the doses necessary. Later on, Dr. H. Zwaardemaker ("Cocain-Anosmie," *Fortschritte der Medicin.*, 1 Juli, 1889") tested the action of cocaine on the sense of smell, and by means of the olfactometer, examined the way in which the smell was affected when cocaine powder of five, ten, and twenty per cent. was blown up the nose. He found that if sufficiently absorbed by the mucous membrane of the upper parts of the nose it produces anosmia, preceded by hyperæsthesia of smell. The various qualities of smell were equally affected.

Tumass ("Uber die Wirkung des salzsauern Cocains auf die psychomotorischen Centren," *Arch. f. exper. Path. u. Pharmakol.*, 1886–87, xxii., 107–126) has shown that cocaine has the same paralyzing influence upon the gray matter of the cerebral cortex. He experimented on dogs, applying from 0.05-per-cent. to 4-per-cent. solutions to the psychomotor centres of the cortex, which had been laid bare by trephining. The result was that, after the application of cocaine, stronger currents were necessary to produce just noticeable contraction of the corresponding muscles. The reduction of irritability lasted fifteen minutes, whereupon it slowly increased, but did not reach the normal within forty-five minutes. The trunks of thick sensory nerves were affected in the same way when moistened with a solution of cocaine; they could be cut without the slightest manifestation of pain. Other observers obtained the same results. The experiments of Goldscheider ("Wirkung des Cocain, etc., auf die Sinnesnerven der Haut.," *Wochenschr. f. prakt. Dermatologie*, 1886, 2), Kochs ("Wirkung des Cocain auf Freipraeparirte Nerven," *Centralblatt f. klin. Med.*, 1886, No. 33), and Alms ("Wirkung des Cocain auf die peripheren Nerven," Du Bois Reymond's *Arch. f. Physiologie*, 1886), show that the application of cocaine to the trunk of a sensory nerve produces peripheral anæsthesia, so that the cocainized part of the nerve seems to constitute an impediment for conduction. The same experience can frequently be made when cocaine is applied subcutaneously for surgical purposes, and the place of application is near a sensory nerve trunk. The action of cocaine upon motor nerve trunks is essentially the same, although the conditions are here so complicated as to make that fact less evident than in the case of sensory nerves.

If a cocaine solution is applied to the trunk of a mixed nerve of a frog, the limb controlled by that nerve seems paralyzed in both its sensory and its motor functions; but upon further examination it is found that the motor paralysis is only a consequence of the muscular and cutaneous anæsthesia (Vulpian, *Comptes rendus*, xcix., p. 887, and Alms, *loc. cit.*), for reflex action can be produced by irritation of other points of the body in the apparently paralyzed muscles. Nevertheless, irritation above the cocainized point (experiments made by Alms on rabbits) discloses a marked decrease in irritability, so that cocaine acts on motor in the same way as on sensory nerves; that is to say, it impedes the conduction of a stimulus. The paralyzing action on the terminal apparatus of the motor nerves has been demonstrated by Alms. If cocaine is injected into the arteria iliaca communis of one side in a frog, precautions being taken at the same time to prevent the cocaine from passing into the general circulation, the muscles of the leg of that side become completely paralyzed; faradic stimulation of the sciatic does not cause contraction, while the muscles retain their direct irritability. Cocaine applied in this way has exactly the same effect as curare has when introduced into the blood circulation.

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* Paper read before the Berlin Med. Soc., January 11th, 1888.

THE ACTION OF COCAINE UPON THE ORGANISM depends of course upon this nerve-stimulating and paralyzing property.

The *Central Nervous System* of all animals is paralyzed by cocaine in sufficient doses after a period of excitation, which latter in warm-blooded animals is characterized by general convulsions, while in cold-blooded animals they are absent. The convulsions are of a general character and of the type of tetanus and opisthotonus; they are certainly of central origin (not reflex convulsions, as they occur at a time when the animals no longer react under the strongest stimulants) and their seat is most likely the medulla oblongata (Anrep, Tumass). The animals die most frequently during these convulsions by suffocation due to tetanus of the respiratory muscles—incidentally as it were; for, if they survive the convulsions, finally paralysis of the entire nervous system sets in, sensibility is lost, reflexes disappear, respiration ceases, the heart stops beating. After very large doses of cocaine this paralysis is developed directly without the intervention of convulsions. [According to the statements of Mosso (*Arch. f. experim. Pathologie u. Pharmakologie*, xxiii., 3, 4, 1887), 0.005 gm. per kilogram will sometimes produce general symptoms of poisoning, while he puts the fatal dose at 0.03 gm. per kilogram. The fatal dose for men is about half that amount.] Small doses, 0.03–0.05–0.1 gm., produce a decided enhancement of the psychical functions, euphoria, and increased capacity for mental and physical work, as shown by the experiments of Freud ("Beitrag zur Kenntniss der Cocawirkung," *Wiener med. Wochenschr.*, 1885, No. 5) and many other observers, with whom the writer, from his own observations, fully agrees. This effect is most likely due to stimulation of the gray cortical matter. The powerful effect which large (but not toxic) doses have in altering the psychical functions (hallucinations, deliria, irresistible impulse to move) is too well known, from Anrep's dramatic description of his experiments on dogs, to be repeated. It will be partly described under the heading, Accidental Poisoning. The exciting effect of large doses is not confined to the cortex. It includes the great subcortical ganglia, the cerebellum, the medulla oblongata, and the spinal cord, as is evident from the forced movements, the vertigo, the convulsions, and the circulatory and respiratory phenomena.

Eye.—The action of cocaine, when introduced into the general circulation, upon this organ is very similar to its action when applied locally; the pupil is dilated, the eyeball protrudes, the eye is opened wider,—symptoms due to irritation of the sympathetic nerve. We must look for the seat of its action upon the sympathetic nerve (when the drug is introduced into the general circulation) in the nuclei of the sympathetic in the cord and medulla, for if the sympathetic is severed in dogs after 0.1 gm. cocaine has been injected into the vena saphena, the above symptoms do not appear on the corresponding side (G. N. Durdufi, "Zur physiologischen Wirkung des Cocain," *Deutsche med. Wochenschr.*, 1887, xiii., 172–174). The dilatation of the pupil after general, just as after local application, must be ascribed to the contraction of the iris arteries, as there does not exist another dilater of the pupil in the human eye.

Respiration.—Cocaine always accelerates the respiration by stimulating the respiratory centrum. Large doses produce very frequent dyspnœic breathing, increasing to tetanus of the respiratory muscles. Fatal doses finally paralyze respiration.

Circulation.—In small and medium doses cocaine increases the frequency of the heart beat, small doses rendering the contraction at the same time more powerful (Mosso). The increased frequency is most likely due to stimulation of the accelerating nerves of the heart (Durdufi). Large doses finally paralyze the heart (the action is different in frogs, the frequency being diminished instead of being increased).

Very peculiar and characteristic is the action of cocaine upon the blood-vessels. Local application has a powerful constringent effect upon the small blood-vessels, making the tissue affected almost anæmic, as we can observe every day when applying cocaine to the nose or to the eye. This action upon the blood-vessels is evidently due to a stimulating effect of cocaine upon the nerves of the smooth muscular fibres. The contraction resulting is of long duration (several hours) and is followed by a relaxation. [Again here we find a difference in frogs. Local application of even weak solutions (1 to 4,000) to the frog's tongue produces considerable dilatation of the blood-vessels.] Introduced into the circulation, cocaine has the same constricting action upon the blood-vessels, and this evidently because it acts upon the centres of the nerves of blood-vessels, as, for instance, is shown by the dilatation of the pupil (anæmia of the iris) not appearing if the sympathetic nerve has been severed. The pressure in the arteries is increased by medium doses in consequence of constriction of the small blood-vessels. Fatal doses lower the pressure accordingly.

The secretion of urine is materially increased by medium doses (even to the double of the normal) just on account of the increase of pressure in the arteries; very large doses diminish and finally stop urine secretion (Bignon: "Des Propriétés toxiques de la Cocaine," *Bullet. gén. de Thérap.*, 1886, ii.).

Intestines.—Peristaltic movements are increased; very large doses paralyze the intestines, which at the same time become very hyperæmic.

Secretion of saliva and perspiration stops after local application, and also when the drug acts by way of the circulation, most likely on account of the paralysis of the secreting epithelium, and constriction of the blood-vessels.

PRACTICAL USE.—*Eye Surgery.*—Cocaine is used for a threefold purpose: As an anodyne in painful affections; as a local anæsthetic in eye operations; as a dilater of the pupil.

Owing to the short duration of the cocaine anæsthesia (about fifteen to twenty minutes), its use as an anodyne is a limited one. Naturally it would be most useful in pains caused by superficial erosions or ulcers of the cornea. The weakening effect upon the vitality of cells (as shown in the paragraphs devoted to the consideration of its action on cell elements) does not make a frequently repeated and prolonged action desirable. It is found very useful in the examination of an eye, where pain, photophobia, and lachrymation would otherwise render such an examination almost impossible, as in conjunctival or corneal troubles, cases of superficially seated foreign bodies, scalding by chemicals, etc. In pains which might possibly be of glaucomatous origin the use of cocaine should be carefully avoided, as it has repeatedly been found to hasten the development of a glaucomatous attack previously threatened (Javal). Supra- or infra-orbital neuralgia can frequently be successfully combated by hypodermic injection. The use of cocaine as a local anæsthetic in eye operations is a very extended one and it has reduced the employment of general anæsthesia by ether or chloroform to a minimum. The objections raised against it in the beginning, of producing sometimes opacities of the cornea after cataract operations, have been silenced by its more judicious application, by prevention of evaporation, and by avoidance of the too free use of sublimate or other coagulating antiseptics. Another objection raised by several writers, that the cocaine anæsthesia renders the eye so hypotonic that the expression in operation for cataract becomes difficult, has not been heard of in the more recent literature. On the contrary, many operators who follow the trend of the time by practising cataract extraction without iridectomy consider the revival of this more perfect method as partly due to the cocaine anæsthesia, the latter being instrumental in preventing prolapse of the iris. While operations on the conjunctiva and on the cornea can always be made perfectly painless by *instillation* of cocaine solutions, such operations in which the iris is touched or cut, as iridectomies and operations for cataract, cannot always be rendered perfectly painless by instillation, owing to the difficulty of making the iris sufficiently anæsthetic. In a number of cases one does succeed in this; in another number one does not.

For making the iris anæsthetic through instillation into the conjunctival sac it is necessary to begin from twenty to thirty minutes before the operation, and continue instilling every five minutes. During this time the eye must be closed to prevent evaporation. To render the iris anæsthetic with certainty, the cocaine must be instilled into the anterior chamber after the corneal section—a proceeding which several surgeons adopted in the beginning, but which was soon abandoned because it proved to be inexpedient. Far superior and absolutely sure in its results is the method of subconjunctival injections which the writer adopted for operations on the tendons and muscles as far back as 1885. Since about 1890 he has used the subconjunctival injections very successfully in cataract operations, iridotomies, and iridectomies, following a suggestion made to him by Professor Snellen, of Utrecht, in a private communication (see also Snellen, "Sur l'opération de la cataracte," *Annales d'Oculistique*, Janvier, 1892). After an experience extending over more than ten years the writer recommends the following procedure: After repeated instillation, to make the conjunctiva and cornea anæsthetic, a speculum is inserted, and by means of a mouse-toothed forceps a fold of the conjunctiva is seized. If the case is one of operation on tendons or muscles, the needle of a sterilized hypodermic syringe must be inserted as deeply as possible into Tenon's capsule, at the point of the intended operation, and a few drops of a five-per-cent. solution are injected. Then the eye is closed again after removal of the speculum and the artificial œdema of the conjunctiva is given time to disappear, which it does in five to ten minutes. Tenotomy can be performed absolutely free of pain. Advancement, however, is not free of pain; it is occasioned by the pulling on the central part of the muscle, which cannot well be reached by the anæsthetic.

If the case is one of iridectomy or extraction of cataract, the site of incision must not be chosen for injection, as the œdematous conjunctiva would be in the way of the knife. It is advisable to make three injections, one below the cornea and one on each side slightly below the horizontal meridian. At each point of injection two drops of five-per-cent. solution are injected under the conjunctiva, care being taken that the needle does not go into the subconjunctival layers, which would produce more swelling than desirable. After five minutes the iris is thoroughly anæsthetic and operations can be performed without the unpleasant and dangerous surprises and disdisappointments that frequently attend an operation which the patient had expected to be painless. In cases of glaucoma—acute and chronic—it is well to use a five-per-cent. solution of cocaine which contains at the same time two per cent. pilocarpine. The writer has practised this method of local anæsthesia for over ten years and has never met with any bad effects which could be attributed to the injection. His results are as good as those of other operators.

The *pupil-dilating* property of cocaine is of great value in ophthalmoscopy. While the dilatation is sufficient in the dark chamber to allow a satisfactory examination, it does not have the blinding effect of belladonna, the pupil all the time responding to light. This is due to the fact that cocaine dilates the pupil by constricting the blood-vessels of the iris, but leaves the sphincter intact. Besides, the accommodation is hardly interfered with. The pupil-dilating power of cocaine, if combined with that of atropine, is invaluable in cases of iritis. The mydriatic effect of this combination is stronger than that of any other drug or any combination of drugs; it counteracts both forces that contract the pupil—the sphincter and the blood-vessels. (Hyperæmia of the iris tends to contract the pupil by stretching the tortuous course of the iris arteries, while the blood-vessels, when empty, return to their tortuous course and so dilate the pupil.)

The anæmia of the blood-vessels is a strong check to the inflammation, the pain ceasing mostly after a few instillations, and the duration of treatment being greatly shortened. The writer uses a mixture of equal parts of a one-per-cent. solution of sulphate of atropine and a five-per-cent. solution of hydrochlorate of cocaine; at first he instils every ten minutes until the pupil is dilated (three to four instillations necessary), then only three times a day. The combination of the two drugs is also efficient in cases of cyclitis.

Rhinology and Laryngology.—In the examination and treatment of the nasal cavities cocaine has an extensive field of usefulness. By its power of constricting the blood-vessels the mucous membrane recedes and inspection of the posterior parts is facilitated; in chronic catarrh with hypertrophy a proper inspection without its help would be impossible. Medicated applications and the actual cautery or caustics can be employed painlessly. In reflex neuroses starting from the nose the exact locality of the trouble can be detected, inasmuch as by application of cocaine to the starting-point the patient is temporarily relieved (asthma, mimic spasm, etc.). In hay fever it affords relief but has no curative power. Posterior rhinoscopy is facilitated by checking the reflex action of the soft palate and the tedious practising of the patient is done away with. The solutions are applied either as a spray by means of an atomizer or with a cotton wad on the point of a probe. For spraying, only weak solutions (two per cent.) should be used, in graduated bottles, so that the quantity used is known, to avoid the possibility of poisoning. Weak solutions applied repeatedly at intervals of five minutes will accomplish the same result as strong ones; the first application constricts the blood-vessels and the following ones act more strongly on the anæmic membrane, while at the same time a too rapid absorption, with its poisonous effects, is prevented. For application with brush or cotton stronger solutions (five, ten, or fifteen per cent.) may be used. Nasal surgery has been greatly promoted by the use of cocaine. Operations on the septum and the turbinated bones can frequently be performed painlessly, although not always so. Laryngological examinations and operations are made easier by stopping reflex action of pharynx and larynx; the practising of the patient is done away with. For making the vocal cords anæsthetic very strong solutions (twenty per cent.) are required; they are applied with brush or cotton.

Otology.—Comparatively little advantage has been brought to otology by the use of cocaine. The drumhead (covered with epidermis) can hardly be rendered completely anæsthetic, but the sensibility can be lessened by repeated application of a warmed fifteen- to twenty-per-cent. solution (Hedinger). In operations in the tympanic cavity more can be expected from the anæsthetic effects of the drug, although only if the operation is limited to the mucous membrane (Kretschmann: "Communication about the results experienced in Schwartze's Clinic," *Arch. f. Ohrenheilk.*, xxiii., 4, 1886). Catheterization of the Eustachian tube is facilitated and made painless; the air penetrates in broader current into the tympanic cavity. Hedinger (*Würtemberg. Corr.-Blatt.*, lvii., 7, 1887) relates favorable results in cases of inflammation of the middle ear. A few drops of a two- to four-per-cent. solution blown into the Eustachian tube by means of a catheter were in most cases sufficient to stop the pain for several hours. Kiesselbach (*Monatsschrift f. Ohrenheilkunde*, xxiii., 9, 1889) had good success from insufflation of a few drops of a four-per-cent. solution into the Eustachian tube in cases of subjective ear noises. The insufflations were made at intervals of from three to five days, the strength of the solution being increased to ten per cent. The most various noises disappeared entirely; most cases improved.

General Surgery.—The use of cocaine in general surgery is very extended, and in minor operations has displaced general anæsthetics and other methods of local anæsthesia. It is injected under the skin or into the deeper layers of the skin at the site of the operation by means of the hypodermic syringe. Careful distribution over the field of operation is necessary for full effect. Corning's method of "incarceration" is an important improvement on the simple injection (J. Leonard Corning: "On the Prolongation of the Anæsthetic Effects of the Hydrochlorate of Cocaine when Subcutaneously Injected—an Experimental Study," New York *Medical Journal*, September 19th, 1885, and "Local Anæsthesia in General Medicine and Surgery," in book form, Appleton & Co., 1886). A short time is given to the circulation to distribute the drug over the field of operation, then exsanguination of the limb and application of a tourniquet (especially devised apparatus on other parts) keep the solution in, place. By this way of proceeding, the anæsthetic effect can be prolonged indefinitely, while absorption into the general circulation and poisonous effects are prevented.

At present extirpation of small tumors, extraction of foreign bodies, amputations of fingers and toes, operation for phimosis, operations for ingrown nail, incision of abscesses and furuncles, are performed under cocaine anæsthesia. Pernice (*Deutsche med. Wochenschrift*, 1890, 14) reports more than a thousand cases operated in the Polyclinic at Halle, where one-per-cent. solutions were used, which were always found sufficient. Not more than 0.01–0.02 gm. was injected, and thus accidents could with certainty be avoided.

In genito-urinary surgery cocaine is extensively used, not only for external and internal urethrotomy, but also for operations in the bladder (litholapaxy). As the unbroken epithelium of the bladder has hardly any power of absorbing, enormous quantities have sometimes been used (1.00–5.00 gm.!!). However, genito-urinary surgery is especially rich in accidental poisoning, the assumption of an unabraded epithelium not always being correct.

Dentistry.—To make extraction of teeth painless it is not sufficient to brush the solution on the gums, as this does not make the alveolus anæsthetic. Even injection between gum and alveolus in one place only will frequently fail. All those who report successful anæsthesia (George Viau: "De l'Anesthésie buccale," Paris, 1886; Bleichsteiner, Congress of Dentistry, Paris) concur in the recommendation to inject the solution under the gum in several places on the inside and outside of the alveolus. A five-per-cent. solution is sufficient, and not more than 0.05 gm. cocaine should be used. Even then one must expect to encounter a larger number of cases in which constitutional symptoms occur than are observed in other branches of surgery. Schlenker ("Ueber Cocain als locales Anaestheticum," *Tageblatt der* 61. *Vers. deutscher Naturf. und Aerzte*, Cöln, 1889) had three per cent. of graver and five per cent. of minor cases of poisoning. Bleichsteiner had collapse in five to six per cent. of his cases.

Gynæcology.—Apart from the use in minor operations on the vulva, vagina, and the cervix, cocaine is especially valuable in the treatment of vomiting in pregnancy, vaginismus, and sore nipples. In cases of vomiting in pregnancy it has been found successful where all other medication failed, whether administered by the stomach, hypodermically, or by application to the os or cervical canal (Weiss: *Prager med. Wochenschr.*, 1884, No. 51—0.004 gm. internally every half-hour; Phillips: London *Lancet*, November 26th, 1887). It is scarcely used any more at present in obstetrics; in the first enthusiasm it was recommended to alleviate pain in labor.

Dermatology.—Cocaine does not have any effect if applied to the unbroken epithelium. If the latter is macerated or wanting, solutions or ointments can be used to combat itching as in vesicular eczema, especially in the itching eczema of the genitals, in painful ulcers, and after cauterizing. In different operations on the skin, and before cauterizing, the application is the same as described under the heading of General Surgery. Touton reports painless treatment by electrolysis of warts or moles, if a few drops of a five-per-cent. solution are injected under the little tumor (which fact the writer can confirm). It is of theoretical interest that cocaine, like other substances, can be driven into the skin by the electrical current if applied to the positive pole—cataphoretic action of the galvanic current (Wagner: "Ueber eine neue Methode Haut-Anaesthesie durch Cocain zu erzeugen," *Zeitschr. für Therapie*, 1886, No. 6). The anæsthesia thus engendered may be used for superficial operations.

In *general medicine* much has been expected from the stimulating powers of cocaine upon the physical functions. However, it does not seem to be extensively used for this purpose, perhaps from exaggerated fear of the cocaine habit. From the experiments of Freud, Hammond, and others it is apparent that it has a decidedly stimulating power upon the psychical faculties, and some writers report very good results in neurasthenic patients and in melancholic depression (0.02–0.3 gm. internally several times a day). According to these observers (Freud: "Bemerkungen über Cocainsucht und Cocainfurcht," *Wiener med. Wochenschrift*, xxxvii., No. 28, 1887) the cocaine habit is not to be feared, as persons, unless they are addicted to the opium habit, can discontinue the use of cocaine without any symptoms therefrom. Preparations of coca in the form of coca wine are extensively advertised and used as a nerve stimulant.

In whooping-cough applications of two- to five-per-cent. solutions to the tonsils, pharynx, and epiglottis have been used with good result (Schuirer, *Arch. für Kinderheilkunde*). Various neuralgias and the shooting pains in locomotor ataxia are a field for the subcutaneous application of cocaine. In tabes, 0.02–0.03 gm. twice a day is reported to have succeeded in cases in which morphine did not have the desired effect. Cocaine has also been recommended in seasickness; however, with little success.

Opium Habit.—The recommendation (Freud: *Centralblatt für Therapie*, July, 1884) to use cocaine in the cure of the opium habit did not meet with general approval, on account of the danger of making the subjects of the opium habit victims of the cocaine habit in addition. As Freud ("Bemerkungen über Cocainsucht und Cocainfurcht," *Wien. med. Woch.*, 1887, No. 28) believes, cocaine is a very valuable agent to combat the craving for morphine and the collapse incidental to the disuse, provided the physician absolutely controls the administration. Obersteiner considers the use of cocaine admissible if no morphine at all is given. He recommends to administer it only internally, the first dose twenty-four to forty-eight hours after the last dose of morphine, giving about 0.05–0.1 gm. several times a day, and not more than 0.5 gm. per day, gradually diminishing the quantity and stopping the administration on the fifth or sixth day.

Accidental Poisoning.—It is not surprising that a drug which came into such rapid and general use in almost all branches of medicine and surgery should have given rise to many and even fatal accidents, partly due to lack of acquaintance with the drug, and partly due to recklessness. The history of cocaine poisoning has already developed quite a literature. Its more judicious use in recent years has greatly reduced the frequency of such accidents. Cases of slight poisoning, which are the commoner ones, offer the following objective symptoms:

Pallor, cold perspiration, frequent pulse, dilated pupils; subjectively the patients complain of dryness of the throat and the lips, a feeling of heaviness in the limbs, weakness, or even vertigo. This condition does not last long, and after a short time (one-half to one hour) complete well-being sets in, even if no restoratives are used. In another class of more serious accidents great mental excitement, with talkativeness, hallucinations, and even delirium, may be present. On the other hand, conditions of syncope and collapse may prevail. In the gravest cases painful dyspnœic breathing, clonic and tonic convulsions occur, which may cause death by tetanus of the respiratory muscles. Or death may result from paralysis of respiration and heart without preceding convulsions. Dr. Paul Mannheim, under the guidance of Leyden, has made a thorough compilation of the accidents hitherto reported in medical literature ("Ueber das Cocain und seine Gefahren in physiologischer, toxicologischer und therapeutischer Beziehung," *Zeitschrift für klinische Medicin*, xviii., 3 and 4, p. 380, 1891). The discussion in the Société de Chirurgie de Paris of a fatal case reported by Dr. Paul Berger, is also of great interest and rich in information ("Empoisonnement mortel produit par l'injection d'une Solution de Chlorhydrate de Cocaine dans la tunique vaginale à la suite de la ponction d'une hydrocèle," *Bulletin et Mémoirs de la Soc. de Chir. de Paris*, 1889, pp. 751, 757, 761, 790).

Mannheim has collected ninety-nine cases from the literature in which the doses used, the symptoms, etc., were stated with sufficient accuracy, and the following account is based upon these cases. The statement frequently made that weak and nervous women are more inclined to constitutional symptoms cannot be accepted; sex does not show any influence. Idiosyncrasy cannot be proven to play a part (the writer fully concurs in this opinion). Although idiosyncrasy against alkaloids certainly exists as a rare exception, it will not do to assume such peculiarity in every case in which a quantity harmless to one individual, produces constitutional symptoms in another. There are other circumstances that should be taken into consideration; for instance, the velocity with which a given amount is thrown into the general circulation. The same quantity in a more concentrated solution will be more quickly absorbed than if dissolved in more water; a tissue richer in blood-vessels will absorb faster than a less vascularized one, etc. For similar reasons it may be that constitutional symptoms occur with relative frequency in operations on the head, which fact has been especially emphasized by Wölfler ("Zur toxischen Wirkung des Cocain," *Wien. med. Wochenschr.*, xxix., 18, 1889) and explained by the nearness of the brain. The sitting posture has been accused as especially aiding the anæmia of the brain, supposed to be the chief cause of the weakness and vertigo in the minor cases. Out of the 99 cases tabulated by Mannheim, cocaine was administered hypodermically in 51, instilled in the eye in 9, in the ear in 2, brushed on the mucous membrane of the nose in 5. Sometimes very small doses produced graver symptoms, sometimes very large doses were followed by very slight ones. The time of appearance of the symptoms varies, being five to ten minutes on an average; sometimes they appeared immediately after administration or after a few seconds, sometimes only after one-fourth or even one-half hour. In the following the symptoms of poisoning are given as collected by Mannheim from the various cases. (The seeming contradiction in the symptoms is not to be wondered at, if it is taken into consideration that cocaine is a poison with first stimulating and afterward paralyzing properties, and that according to quantity or velocity of absorption the first or the second will prevail.)

General Symptoms.—The patients become sleepy and get into a soporous condition; they almost lose consciousness and faculty to articulate, or they fall within a few minutes into a very deep sleep of comatose character. Severe collapse has been observed, preceded by weakness, with complete loss of consciousness of long duration and with reduced respiration. In other cases the patients become very restless and excited, seem dizzy, cry and laugh alternately, gesticulate, and are very talkative, not heeding any questions put to them; incessantly change their position, stand up, sit down; their gait becomes unsteady, like that of a drunken person. This condition grows into intoxication, or a feeling of impending death. There may be sleeplessness, lasting from thirty to forty hours; afterward complete forgetfulness of what has happened.

Central Nervous System.—In mild cases reflexes are increased; there are cerebral irritation and delirium, lasting as much as an hour, and hallucinations. In severe cases there are epileptiform attacks, with general clonic convulsions, lasting even five hours, tetanus, opisthotonus, death.

Peripheral Nerves.—Sensibility diminished. Complaints of loss of sensation over the whole body or on single parts, limbs, or pharynx. Sometimes only numbness, sometimes complete anæsthesia. Feeling of intense coldness in the anæsthesic parts. Various paræsthesias. On the part of motor nerves twitching of single muscles (or, as already mentioned, general convulsions), in other cases heaviness or tired feeling in the limbs, sometimes aggravated to apparent paresis. Gait staggering or complete inability to walk.

Eye.—Pupils dilated, sometimes very contracted; reacting in some cases, in others motionless. Some patients complain of darkness before the eyes, others notice diminished acuteness of vision, complain of mist before the eyes; in some instances complete amaurosis (transient). One lady recovered vision only after four hours.

Other Special Senses.—Buzzing in the ears, various disturbances of smell and taste.

Respiration.—Short, whistling, laboring. Paroxysms of dyspnœa. On the contrary, the frequency can be diminished (even to nine respirations in the minute) and may cease, so that death occurs by asphyxia. Sometimes Cheyne-Stokes respiration has been observed.

Circulation.—Pulse very accelerated, often very weak, filiform, irregular, at last hardly or not at all perceptible. In other cases, pulse less frequent. Diuresis increased according to some writers, diminished and even suppressed according to others.

Organs of Digestion.—Numbness of the throat, astringed sensation and dryness in the pharynx, dysphagia. Burning pain in mouth and stomach (even after hypodermic administration). Pain in intestines. Rectal and vesical tenesmus.

Cause of Death.—Paralysis of respiratory and vasomotor centres and heart, whereas in other cases death results from tetanus of respiratory muscles.

Autopsy showed, in the few cases examined, intense hyperæmia of the brain and of the inner organs.

Fatal Dose.—In five of the fatal cases the dose was larger than 1 gm., whereas only one patient who had been given 1.25 gm. recovered. From this Mannheim concludes that 1 gm. is to be considered the fatal dose.

Of the 99 cases thus compiled, 9 were fatal. Besides, there are 100 cases in literature in which no symptoms are mentioned. Of Mattison's 108 cases, 58 are included in Mannheim's table, whereas 50 are not. This makes altogether 250 cases with 13 fatal results, so that of the accidents reported five per cent. proved fatal. (Considering that most of the graver and fatal cases are reported, while the much more frequent minor accidents do not come to general cognizance, the figure five per cent. is certainly too high.)

Treatment of Cocaine Poisoning.—In the minor cases, in which weakness and dizziness prevail, horizontal position of the patient and administration of stimulants, like brandy, coffee, ether, are the reasonable measures to be taken. Inhalation of a few drops of amyl nitrite has been recommended, and is the measure generally adopted to combat the supposed anæmia of the brain. For the severe cases in which convulsions occur, Mosso, from his experiments on dogs, comes to the following conclusion: "If it were necessary to assist a human being poisoned with cocaine, one would have immediately to resort to ether or chloroform to prevent tetanus of the respiratory muscles, which is the most frequent and dangerous cause of death. After the first grave and imminent danger has passed, chloral can be given. If respiration stops, artificial respiration must be resorted to."

Dose.—Internally 0.02 to 0.05 gm. several times a day may be considered a safe dose, and even 0.1 gm. may be given. For hypodermic use in operations it is advisable to keep under the 0.05 gm. limit. Weak solutions of one per cent. and two per cent. should be used, well distributed over the field of operation. For spraying (nose, throat) weak solutions (two per cent.) should be used in known quantity. For operations in nose, pharynx, and larynx, brushing with strong solutions cannot be avoided, but in these cases the danger is obviously less because the quantities used are small. Careful watching of the patient and gradual administration in all cases will increase the safety of continued administration.

Cocaine Habit.—Most subjects of the cocaine habit are victims of the opium habit who have taken cocaine for the purpose of curing themselves, have not succeeded in their efforts, and have consequently become addicted to both drugs. It is therefore not easy to state the symptoms of the cocaine habit pure and simple. Luff (London *Lancet*, September, 1889) tells of a man who used 0.25 gm. daily during three years for nasal catarrh, and who in consequence was very much reduced physically, mentally, and morally. He became unsociable, incapable of attending to his business, because unable to come to any decision. Palpitations of the heart and obstinate constipation were also among the symptoms from which he suffered. Bauer (New York *Medical Record*, November, 1885) tells of a man who replaced the use of alcohol by daily injection of 0.67 gm. cocaine. He became very weak, lost all appetite, had attacks of delirium, and ultimately fell into complete physical and mental decay.

From all observation it appears that rapid falling off in flesh is one of the most prominent somatic symptoms of the cocaine habit. Erlenmeyer (*Deutsche med. Zeitung*, 1886, p. 483) reports a falling off of twenty to thirty per cent. within a few weeks, without diminution of food and with no existing catarrh of the stomach. He lays great stress on the respiratory and vaso-motor disturbances caused by the blood-vessel-paralyzing properties of cocaine: frequent pulse, relaxation of arterial system, profuse perspiration, syncope. The psychical symptoms are very marked and characteristic, and in well-developed cases offer the clinical picture of hallucinatory paranoia. They consist, according to Obersteiner, chiefly of feelings of fright caused by hallucinations, especially in the visual and sensory spheres. Either terrible apparitions are seen or great hordes of small animals. These latter hallucinations are most likely based on itching paræsthesias of the skin, giving to the patient the impression of the presence of insects or worms under the skin and causing him to scratch. There exists an interesting observation of Ehrlich's, in his experiments with mice above mentioned, which closely recalls these paræsthesias and hallucinations based upon them. One of his mice, after three weeks' use of cocaine, began to gnaw its limb, so that in the course of the next few days the whole right thigh down to the knee was entirely denuded. Ehrlich's explanation of this remarkable fact is that paræsthesias due to degeneration of the peripheral nerves provoke the gnawing, while the simultaneous anæsthesia of the skin leaves the latter without the protection of sensation.

While some writers deny the existence of symptoms due to withdrawal of cocaine in cases of well-formed habit, others, like Obersteiner and Erlenmeyer, affirm the contrary. According to Obersteiner they frequently appear only after the lapse of a fortnight and consist of sudden collapse and a feeling of impending death. Erlenmeyer emphasizes the vaso-motor disturbances as palpitation, weakness of the heart, dyspnœa, syncope, depression of humor, enormous weakening of the will power. According to all writers the prognosis of the cocaine habit is not a good one, as patients very readily relapse. It is reported that the habitual use of cocaine among the negroes in our Southern States is deplorably common, and that, no adequate restrictive measures upon its sale being in force, it is on the rapid increase.*

Carl Koller.

COCCIDIA. See *Protozoa.*

COCCULUS INDICUS. (TOXICOLOGICAL.)—Cocculus indicus is the dried fruit of *Anamirta paniculata* or *Menispermum cocculus*, order *Menispermaceæ*. It is a climbing plant indigenous to Asia, India, and the neighboring islands. This fruit or berry is also known as Coccus indicus, cocculus, Indian berry, Indian cockle, fish berry, fisher's berry, and Levant nut. The berry is shaped somewhat like a kidney, and is about the size of a small marble. It consists of a light yellow seed of excessive bitterness, covered with a woody shell. The external coat is of a dark-brownish color. This fruit has been used to adulterate beer and ale in order to make them more bitter and inebriating. It is extremely poisonous to fish, and on this account has often been put into the water of fish ponds. It enters into the composition of various decoctions for killing vermin. Of late years the chief importance of this berry consists in its being the source of picrotoxin. The shell contains two inert principles: menispermin and paramenispermin. Picrotoxin ($C_{30}H_{34}O_{13}$), the active principle, was discovered in 1820 by Boullay. This drug may be prepared by extracting the berries with boiling alcohol. The crystals are odorless but very bitter, neutral, and soluble in caustic ammonia; also in a large proportion of cold water, far more easily in hot water, and in thirteen parts of alcohol. There are no official preparations of Cocculus indicus except picrotoxin itself. The *antagonist* is chloral, which opposes its cerebral and spinal effects, although it has the same depressing power over the heart and respiration. Anæsthetics control the convulsions incident to the overdose of picrotoxin; and acetic acid also affords relief.

The *physiological action* of pictrotoxin is that of a cerebro-spinal stimulant, affecting particularly the centres in the medulla. It slows the action of the heart as well as respiration after having accelerated them transitorily.

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* As Dr. Koller's connection with the employment of cocaine as a local anæsthetic has often been stated erroneously, I requested him to furnish me with a brief account of the actual facts, in order that I might publish it as an addendum to the main article on this drug. From the letter which I received from him in response to my request I quote the following:

"The events which led to the therapeutic use of the anæsthetic properties of cocaine were by no means accidental, as represented. On the contrary I had, one year before the summer of 1884 (the year in which my cocaine experiments were made), experimented with various substances (morphine, bromide, chloral, etc.), in order to find a local anæsthetic which I thought would be valuable in eye operations, as the general anæsthesia, with its sequels of vomiting, etc., is not desirable for these operations. I gave these experiments up as unsuccessful, but my mind was prepared to grasp an anæsthetic as soon as it presented itself. It happened that my friend, Sigmund Freud (Privatdocent of Neurology in the University of Vienna), was making experiments on the physiological action of cocaine, and he gave me some to take internally. I took it and felt the numbness of the tongue, and said to myself: Here is an anæsthetic. I went at once into Stricker's Laboratory, where I took a guinea-pig and made the experiments which established in my mind the usefulness of cocaine as a local anæsthetic. In less than two weeks the experiments were finished. I gave to Dr. Brettauer, of Trieste, a vial of the solution. He was travelling through Vienna to Heidelberg, to attend the meeting of the German Ophthalmological Society, and there he exhibited for the first time my experiments. That cocaine makes the tongue numb was nothing new, but could be found in every text-book on toxicology. That the anæsthesia of the eye cannot be discovered *accidentally* by a drop squirting into one's eye—which fanciful accident has been alleged as the cause of my so-called discovery—is best shown by the fact that another friend, who, upon the suggestion of Dr. Freud, tried the 'astringent' effect of cocaine in conjunctivitis and trachoma, and who did put it into his own and other people's eyes, failed to notice the anæsthesia. Physiologists had before me put it into the eyes and noted dilatation of the pupil, but had not grasped the idea of a local anæsthetic.

"After I had established, to my own satisfaction, the usefulness of cocaine in eye surgery, I induced Dr. Jellinek, a laryngologist of Vienna, to use it in the larynx. To what extent it was used, shortly or immediately after this, in other branches of medicine, is known.

"What I may justly claim for myself is, not that I introduced cocaine into eye surgery, but that I originated the idea of a local anæsthetic." Editor of REFERENCE HANDBOOK.

The brain is not affected to any extent. Picrotoxin has a marked local action, stimulating all the secretions, especially those of the intestines. Röhrig noted uterine contractions. In over-doses its action is much like that of strychnine. It can be differentiated by the character of the spasm produced: that caused by picrotoxin is choreic, affecting chiefly the flexor muscles; that due to strychnine being tetanic, and affecting chiefly the extensors.

The *symptoms* are twitchings and inco-ordination of the muscles, increased reflexes, spasms, convulsions, delirium, stupor, coma, death from cardiac paralysis; glottic spasm, burning taste, pain in the throat and stomach, vomiting, and diarrhœa. The breath is very characteristic.

As to the *fatal dose,* according to Blyth, probably from two to three grains would be dangerous for an adult. The frog, which seems the most suitable animal for experimentation with this drug, shows an extreme abdominal swelling as a result of its ingestion. There are very few fatal cases of poisoning by picrotoxin in man on record. The absorption of this drug by the stomach and by the body surface is rapid. The method of its distribution in the tissues has not yet been clearly demonstrated. Neither is its excretion by the urine well understood, although the poison has been detected unchanged in this excretion.

The *post-mortem* changes offer very little which is characteristic. According to Kobert the brain and lungs are congested. The heart is flabby and the salivary glands are swollen. There may be signs of gastro-intestinal irritation and peritonitis.

Kobert gives the following method of separating picrotoxin from the organism: "The extracts from the organism, purified by means of neutral plumbic acetate and freed from lead, yield picrotoxin to amylic alcohol or chloroform. It will reduce alkaline cupric sulphate solution. Evaporated with concentrated HNO_3, then touched with concentrated H_2SO_4, and, finally, upon addition of NaOH solution, it turns brick-red. With H_2SO_4 alone, a saffron-yellow appears." When in aqueous acid solutions, picrotoxin can be extracted by chloroform, amyl alcohol, or ether. After evaporating the solvent the crude picrotoxin can be crystallized out of water and examined.

A *test* which may be applied is as follows: The suspected picrotoxin is dried and mixed with three times its amount of saltpetre. A little H_2SO_4 is added, after which the mixture is decomposed by an excess of soda lye, when there will appear a transitory brick-red color.

The *treatment* consists in the use of the stomach-pump or in the administration of emetics, *e.g.*, mustard, zinc sulphate, or apomorphine subcutaneously. Chloroform is valuable when convulsions take place. Amyl hydrate and paraldehyde are useful as antidotes. In order to allay tetanus, chloral. gr. x. to xx. every half hour, may be administered: the effects must be watched. Or, ʒ i. of potassium bromide, or, in severe cases, ʒ i. of the bromide with gr. xx. of chloral may be given.

Emma E. Walker.

CŒLIO-HYSTERECTOMY. See *Cæsarean Section.*

COCCYGODYNIA.—For this term, sometimes written coccydynia, medical nomenclature is indebted to Sir James Y. Simpson, who gave the name to a painful affection of the coccyx, or of the parts in intimate relation with that bone—claiming for the name the negative merit that it conveyed no erroneous impression concerning the pathology of the disorder.

It is probable that the term embraces several distinct diseases, some of which may be simply neuralgic; some, possibly, rheumatic; some only sympathetic; while others are certainly due to organic degeneration of the bony structure itself, or to fracture or dislocation of the bone.

As the name implies, it matters not what may be the morbid condition which gives rise to it, pain in the region of the coccyx is the symptom that calls into exercise the resources of the medical art.

The affection is more common in women than in men, and is most frequently encountered in women who have borne children, though it is by no means confined to them. It may continue indefinitely, if left to itself, and the pain is sometimes very severe.

The pain is provoked by pressure, by any movement of the bone, or by contractions of the muscles attached to the coccyx. Sitting, and especially rising from the sitting posture, ascending stairs, walking, defecation, and even micturition in some cases, occasion paroxysms of intense suffering.

The principal causes of coccygodynia are direct violence to the coccyx, injuries inflicted during parturition, the influence of cold, and uterine, ovarian, or rectal disease.

The *diagnosis* is not attended with difficulty. A thorough physical examination will always remove any obscurity and enable the surgeon to detect, by means of bimanual manipulation with one finger in the rectum, any displacement of the bone and to distinguish between this affection and painful hemorrhoids, anal fissure, foreign bodies within the rectum, or any other pelvic disorder with which the symptoms may be associated.

A favorable *prognosis* may always be given, unless the pain should be dependent upon some incurable disease elsewhere; otherwise, with proper treatment, complete relief can be promised.

The *treatment* should, of course, vary to meet the conditions that may be present. If, upon investigation, the affection is found to result from uterine, ovarian, or rectal disease, curative measures should be addressed to the primary disorder. In the absence of any such exciting cause, or of any displacement or appreciable disease of the bone, the remedies appropriate in the several forms of neuralgia may be resorted to with a fair prospect of success. Among the most potent of these are opium, quinine, arsenic, salicylate of sodium, blisters, and electricity, and such general medication and such management as the condition of the patient may require.

In the event of failure after a faithful trial of this plan, surgical interference should be confidently advised. Two procedures are available.

One consists in the isolation of the coccygeal bones from the surrounding tissues, by means of a tenotomy knife; the other, first practised by Dr. J. C. Nott, of Mobile, in the removal of the coccyx entire, or of the lower part of the bone.

A modification of the operation proposed by Dr. Nott was suggested a few years ago by Dr. Garretson. He exposes the bone by an incision through the skin, and by means of a "burr" attached to a dental engine, the bone is ground away to any desired extent, leaving the periosteum upon the anterior surface, with all of its attachments, intact.

In the great majority of cases, the thorough division of the muscular and tendinous structures surrounding the coccyx will suffice, though occasionally the extirpation or the enucleation of the bone, or a portion of it, will be found to be necessary to effect a permanent cure.

The complete excision of the bone is followed by no lasting inconvenience, and most surgeons would prefer to do the radical operation at once, rather than incur the risk of failure by doing only a little less, and thereby subject the patient to the ordeal of a second operation.

The operation is made by an incision over the coccyx. All attachments to the borders and to the apex are severed close to the bone by blunt scissors. The apex being thus freed, the bone is drawn strongly backward and attachments to the anterior surface are divided. Disarticulation from the sacrum is then accomplished and, after arrest of all hemorrhage, the wound is closed. On account of the depth and size of the cavity, accurate coaptation by tiers of catgut sutures is recommended.

In one case which has come to the attention of the writer—the case reported by Dr. Floyd W. McRae—relief was not obtained by the ablation of the coccyx entire, but was secured only by the subsequent removal of the sacral bursa and of Luschka's gland, both of which were enlarged.

James B. Baird.

COCHINEAL. COCCUS.—"The dried female of Coccus cacti L." (U. S. P.).

The cochineal insect is a native of Mexico and Central America, where it abounds as a parasite upon several genera of *Cacti*, especially the Opuntias. It is also found, probably native, in the West Indies. For commercial purposes, however, it has long been bred and raised upon *Nopalea Cochinillifer* (L.) Lyons, *Opuntia Tuña* (L.) Mill, and other species of Opuntia which are cultivated in plantations for the purpose. The pregnant females, about two hundred times as numerous as the males, placed upon them, deposit their numerous progeny. which feed and live upon the plants. These when fully grown (and pregnant) are collected, killed by heat, and dried. This insect, together with its foster plants, have been introduced into the West Indies, East Indies, Java, Southern Europe, and Africa.

Description.—The dried cochineal is described as follows: "About one-fifth of an inch (5 mm.) long; of a purplish-gray or purplish-black color; nearly hemispherical; somewhat oblong and angular in outline; flat or concave beneath; convex above; transversely wrinkled; easily pulverizable, yielding a dark-red powder. Odor, faint; taste, slightly bitterish. It contains a red coloring matter, soluble in water, alcohol, or water of ammonia; slightly soluble in ether, insoluble in fixed and volatile oils. On macerating cochineal in water the insect swells up, but no insoluble powder should be separated."

Cochineal, being an expensive article, is subject to much adulteration; crude foreign substance, like stones, starch, tapioca, etc., and insoluble and heavy earths caused to adhere, are easily detected. The most difficult to recognize is the substitution of partially exhausted, for fresh insects; this can be detected only by a sort of assay for the coloring powder left in them.

The wild *Cocci* are collected in Mexico and elsewhere to supply an inferior grade of cochineal. Besides, *Coccus Ilecis* Fabricius, Kermes is a larger species, living upon a species of oak (*Quercus coccifera* Linn.). It is collected and dried in Southeastern Europe, and has constituents similar to those of *C. Cacti*, but the color is inferior and less in quantity.

Composition.—Good Honduras cochineal contains, according to Hager, six per cent. of *moisture*, from fifteen to eighteen of *fat*, from forty to forty-five of *carminic acid*, from three and a half to five of *ash*, and from seven to eleven of insoluble residue. Of these the only one of use is the carminic acid or coloring matter, a brilliant red powder, soluble in water and alcohol, but insoluble in dilute acids. It is the basis of carmine, and the different pink, purple, and other beautiful *lakes* used in painting and dyeing.

Uses.—Like nearly everything else that can be in any way swallowed, this too has been used in medicine as "anodyne, tonic, astringent." It has no medicinal value whatever, and is wholly consumed at present in the manufacture of dyes and paints. In pharmacy and confectionery it is frequently used for its color.

W. P. Bolles.

COCILLANA.—The bark of *Guarea Rusbyi* (Britton) Rusby (fam. *Meliaceæ*), a good-sized tree. The writer, in 1886, found this bark in use among the Indians of Bolivia as an emetic and purgative, and recognized by them as a fatal poison in overdoses, the symptoms being those of poisoning by ipecac, though with rather more irritation of the intestine. Its medicinal action is also in general like that of ipecac. It contains a little tannin, two resins, and the alkaloid *Rusbyine* (*Eccles*). The two latter are active and overcome the effect of the tannin, producing a laxative effect. As an expectorant, cocillana acts within half an hour, stimulating the secretion of the bronchial mucous membrane and producing a free flow of mucus; this continues for some hours, and is followed by diminished activity of the glands. It has very little action on the skin. It has proved of greatest service in chronic and subacute bronchitis when the secretion is scanty and tenacious. In such cases, it liquefies the secretion and stimulates expectoration. The fluid extract, in doses of ♏ x. to xx. every three or four hours, seems to have been the most serviceable means of securing its effects. In the early stages of acute inflammation it should not be given. In bronchorrhœa and in the aged, with profuse secretion, it is not advised, as it does not stimulate the respiratory organs, and might produce too free secretion within the tubes. In phthisis it has to be used with caution on account of its irritant action upon the digestive tract, and the danger of producing inflammatory foci in the lungs.

Henry H. Rusby.

COCOA BUTTER. See *Cacao, Butter of.*

COCONUT, OIL OF.—*Oleum Cocos.* The fat obtained from the albumen of the seed of *Cocos nucifera* (L.) (fam. *Palmaceæ*). This magnificent palm, a native, perhaps, of tropical Asia and many islands of the Pacific and Indian Oceans, is cultivated in all warm countries for its edible seeds and numerous useful products. Its well-known fruit and seed are among the largest in the world. Several methods are employed in separating the oil, and give rise to some diversity of appearance in the product. That obtained by cold expression is softer, and melts easier than the oils obtained by heat. These also vary according to the degree of heat and method used. Sometimes the pulp is simply warmed and then expressed as above, at other times the oil is boiled out as lard is in the country. The yield is about fifty per cent. The oil varies in consistence from that of hard lard or butter, to that of petroleum, in the summer, and melts between 60° and 80° F. It is greenish-white or creamy-white in color, and has a lard-like odor, with, in most specimens, a certain degree of rancidity. Taste, when fresh, not disagreeable. It is a rather complicated substance, and contains free and combined fatty acids, both fixed and volatile. Among the principal glycerides are those of *palmitic*, *caprylic*, *myristic*, and *lauric acids*, also those of *stearic* and *caprinic acids*, and others.

In the countries where it is produced, coconut oil is used for all the every-day uses of such fats—food, fuel, light, soap, etc. In temperate climates it is not likely to displace the olive, cotton-seed, almond, and many other oils like them, with which those countries abound. It is, however, abundant and cheap, and when good, not disagreeable—and well adapted to fill the place of lard and other animal fats in the preparation of ointments and cerates. It has been given as a substitute for cod-liver oil, but with no particular advantage. It is very largely used in soaps. A butter, to be distinguished from Cacao butter, is made from this oil which possesses the merit of enduring hot climates without becoming rancid, and this has been recommended for military and naval uses. Distinct tænicidal properties are recognized in the domestic uses of coconut oil, and large doses (℥ ij. to iv.) have proven efficient in intractable cases of tapeworm.

Henry H. Rusby.

CODEINE, CODEINA.—($C_{17}H_{17}$ [OCH_3] [OH]NO + H_2O). This alkaloid, which is chemically *methyl morphine*, is obtained from opium to the average extent of about one-half of one per cent. Its solubility in water, about gr. vi. to the ounce, as well as in alcohol, is noteworthy. It is thus described in the Pharmacopœia:

"White, or nearly translucent, orthorhombic prisms, or octahedral crystals, odorless, having a faintly bitter taste, and slightly efflorescent in warm air.

"Soluble, at 15° C. (59° F.), in 80 parts of water and in 3 parts of alcohol. In boiling water codeine melts into oily drops which dissolve in 17 parts of the water. It is very soluble in boiling alcohol; also soluble in 30 parts of ether and in 2 parts of chloroform.

"At 100° C. (212° F.) codeine loses its water of crystallization (5.67 per cent.); at 155° C. (311° F.) it melts, forming a colorless liquid; and, when ignited, it is consumed without leaving a residue.

"Codeine is neutral to litmus paper.

"Codeine is dissolved by cold, concentrated sulphuric acid (free from nitrose) without producing a color.

"If about 2 c.c. of this solution be poured into a small porcelain capsule, and 1 drop of highly diluted nitric acid (made by adding 1 drop of nitric acid to 100 c.c. of water) added, a bluish or blue tint will be developed.

"Another portion of this solution, of about 2 c.c., gently warmed, and mixed with 1 drop of a mixture of 1 volume of ferric chloride T.S. and 19 volumes of water, likewise assumes a bluish or blue tint (difference from *morphine*).

"On adding to 5 c.c. of an aqueous solution of codeine (1 to 100) 10 drops of bromine water, and shaking so as to redissolve the precipitate formed, the liquid will gradually develop a light claret-red tint. This tint may be developed at once by the addition of ammonia water.

"On sprinkling 0.05 gm. of codeine upon 2 c.c. of nitric acid (specific gravity 1.200), the crystals will turn red, but the acid, even when warmed, will acquire only a yellow color (difference from and absence of *morphine*)."

Although no salt is official, salts with most of the acids ordinarily used for such purposes are in the market. All are soluble in very small amounts of water except the sulphate, which requires 40 parts and the hydrochlorate which requires 20 parts.

The properties are in general similar to those of morphine, but it cannot subdue pain. Light irritations, however, yield to it. It depresses the cerebral functions, and if there be not much pain or other preventive cause, induces sleep. This is followed by increased excitability. It therefore appears that, just opposite to morphine, its primary action is depressant, its secondary stimulant, a fact which is commonly true of methyl compounds as compared with the substances so combined. It thus follows that the secondary effects are secured more promptly and strongly with increase of dosage, and for an anodyne the dose must be kept down. The most common use of codeine is as a respiratory sedative. It does nothing to cure the condition but relieves the disturbance, reduces the cough and thus permits sleep. It will also reduce the amount of sugar in the urine. It has been used to favor recovery from the morphine habit. The dose is 0.03 to 0.1 gm. (gr. ss. to iss.). For hypodermic injection the dose is about half as great. *Henry H. Rusby.*

COD-LIVER OIL.—OLEUM MORRHUÆ. *Oleum Jecoris Asellæ.* "A fixed oil expressed from the fresh livers of Gadus Morrhua L., and of other species of *Gadus*" (U. S. P.). The similar oils from the pollock, hake, and haddock have also been much used, but are not now officially recognized. The English and German Pharmacopœias unite in requiring the oil to be expressed without much heat. The United States does not limit the heat, but the requirements of the market here effectually exclude oils in any way injured in extraction. The British Pharmacopœia requires that the solid fat be filtered out at about 23° F.

The codfish is too well known to require description. It is very widely distributed and abundant, inhabiting the temperate and colder parts of both the Atlantic and the Pacific Ocean.

Cod-liver oil is prepared in several ways, according to the character of the fisheries and the use to which it is put. If the fishermen are far from shore, as on the Banks, where the boats remain out perhaps for several weeks, the livers are thrown, as the fish are cleaned, into barrels, where they lie until putrefaction begins, and the oil escaping from the decomposing cells rises to the top. This is then drawn off. Upon returning to the shore, the remaining pulp is boiled and the rest of the oil strained out. Such products are dark in color, offensive-smelling and unfit for medicine. The pale, sweet oils are made by fishermen who catch near shore, and every day or two land with their fish; they separate the oil at once from the fresh and clean livers. The common way is simply to scald the livers in water until the tissues become disintegrated, when the mass is strained through cloths, the water and oil finally separating from each other upon standing. The best method is to heat the livers in a vat or barrel by means of injected steam until they become softened, and then strain them and allow the oil to separate as above. Most of the fine oil used in this country is prepared in this way during the winter months, and then has also a portion of its stearin, etc., removed by freezing and expression. Some of our fine oil is manufactured on the New England coast; that of Europe, in Norway, Scotland, and England. The better grades of Norwegian oil are now very extensively imported for medicinal use here. The best is the Loffoten.

Cod-liver oil has had some reputation as a medicine for a century or more, but its extensive and most important use in phthisis is less than half as old.

The quality of oil suitable for dispensing is a pale yellow liquid of faint fishy odor, and a peculiar, at first not very marked, but finally disagreeable, slightly acrid taste. It does not dissolve in alcohol, but, like all fats, is readily soluble in ether. Its specific gravity is about .922. "If one drop of the oil be dissolved in twenty drops of chloroform, and the solution shaken with one drop of sulphuric acid, it will acquire a violet-red tint, rapidly changing to rose-red and brownish-yellow (U. S. P.). In addition to the above test, and others, a cultivated taste and smell are necessary to judge of the quality, or even genuineness, of the drug.

COMPOSITION.—Although a complex mixture, it is not known how far its value depends upon its complexity; certain it is that the modern clear and comparatively agreeable oils contain less of the unusual ingredients than the older ones, and that some of these ingredients, at least, were cadaveric products of decomposition of the livers, or empyreumatic decompositions brought about by the method of manufacture. These clear and light oils are more efficient as medicines, as they certainly are less disgusting, and can be taken by numerous persons who could not endure the others.

The very different action of cod-liver oil from that of other animal fats consisting of olein, palmitin, and stearin has recently been explained, by the announcement that its constituents are chiefly therapin and jecolein, fatty substances very different from those above named. On the other hand, assuming it to have the usual composition, the most extensive efforts have been made to discover in it something in the nature of an active constituent. Iodine, bromine, phosphorus, cholesterin, and bile acids have all in turn been credited with the peculiar properties of the oil, but these theories have been successively abandoned. Free acids are less in amount in the better oils, and the same is true of the several alkaloids which have been discovered, especially trimethylamine, aselline, and morrhuine. This question is of great importance, as it determines our ability or inability to secure the effects of the oil from extractive preparations. It may, however, be truthfully affirmed that this has not been found possible. The body of the oil must be assimilated in order to get its benefits, and the above theory as to its fatty substances being *sui generis* is the only one which presents elements of probability.

ACTION AND USE.—This is the most readily absorbed and assimilated of oils. A loop of intestine containing it, compared with another containing another oil, is said to show an appreciable gain over the other in absorption. It is natural, therefore, that, added to other food, it should increase nutrition and the accumulation of fat. This quality is sufficient to explain its usefulness in the treatment of cases of simple emaciation, from bad nutrition, in chronic and wasting diseases, at the end of fevers, etc. So far, it can hardly be considered a medicine, but only a particularly useful form of non-nitrogenous food. It is emulsified and absorbed exactly as other oils are, and undoubtedly becomes in the same way a part of the bodily tissues. In this view, other oils should have the same effect according to their assimilability, and suitable doses of olive, linseed, and lard oils should be equally as good, and cream, from its state of emulsion, even better. Experience has not, however, confirmed their equality. The most important uses of cod-liver oil, moreover, are observed in a series of cases whose pathology is as obscure as the action of the remedy—such as the "scrofulous" diseases, whether glandular or ulcerative, chronic rheumatism, etc. It must in these cases act in some gentle and peculiar way upon the pathological processes, tending to return them to normal physiological ones, and in this respect is to be classed in the heterogeneous number of medicines called alteratives. Its uses have been mostly noticed in the preceding sentence but may be recapitulated a little more in detail. It is given, more than in any other disease, in phthisis pulmonalis. The long, wasting course of this complaint calls very distinctly for remedies that will prevent waste on the one hand, and promote nutrition on the other. Alcohol and cod-liver oil may be regarded as types of these two therapeutic agents, and experience has long ago shown them to be two of the most generally useful things that can be given. Neither is a specific, neither appears in the slightest degree to change the character of the poison lying at the root of the complaint, but both retard the loss of flesh and strength, each in its peculiar way. The oil is often given alone in the early stages of the disease, and generally with advantage, as alcohol in small doses more readily loses its effect. It is also frequently combined with malt extracts, the hypophosphites, iron, iodine, and other alteratives or aids to nutrition. Besides the general action, the oil has an undoubted favorable effect upon the chronic bronchitis and catarrhal pneumonia present, and it is therefore of value in the cough of consumption. It is also of great service in subacute and chronic idiopathic bronchitis ("colds in the chest"). In the persisting colds of infants and the aged, with a good deal of weakness, it has no equal. In chronic catarrh of various mucous membranes, ear, nose, vagina, urethra, etc., especially if attended with, or depending upon, debility, it is sometimes useful. In hip disease, and similar degenerations of other joints; in glandular abscesses, in chronic ulcers; in short, wherever there are waste, emaciation, and thinness of blood, it is to be tried. A peculiar method of its employment in the fisheries is in half-tumblerful doses, to break up an acute cold.

The great obstacles to the fullest use of cod-liver oil are its taste, which is so repugnant to many that they can scarcely take it, and its liability to disagree with the stomach, and either to produce nausea and vomiting, or, what is equally disastrous, to impair the appetite and so to more than undo all its possible benefit. The different methods of administration mentioned below sometimes overcome this, but most important is the exclusive use of the carefully prepared and nearly tasteless oils referred to above.

Administration.—The dose of the oil is from 12 to 30 c.c. (ʒ iij. ad ℥ i.) two or three times a day. If it can be taken clear it may be so given; the taste, even of the best, is somewhat repulsive, and becomes more so toward the last of the bottle in summer, as it rather easily becomes rancid. It is best, therefore, to purchase only a small quantity at a time, and to keep it as cool as possible. The taste may be disguised by means similar to those used with other oils (*e.g.*, *Castor Oil*, *q.v.*): rinsing the mouth thoroughly with whiskey, spirit of lemon, peppermint, or some such pungent vehicle; swallowing the oil at once, and again rinsing the mouth, is as good as any of the extemporaneous means used for this purpose. The liquor, if one prefers to do so, may be spit out. Large elastic capsules containing 6 or 8 gm. (ʒ i. to ij.) are made, but not much used, on account of their expensiveness. The following combination, when liquor is to be given with it, is a well-known favorite:

Cod-liver oil	50 parts.
Whiskey	35 "
Comp. tincture of lavender	15 "

It must be thoroughly shaken for every dose, as the oil immediately begins to separate. The lavender is added only as a flavor, and may be omitted. All oils appear to be less offensive to children than to adults.

Another method is to mix the oil with about an equal part of one of the syrupy malt extracts; the mixture does not separate so readily as the above. Its taste is well borne by children. Then there are the numerous emulsions made and advertised everywhere. They come under one of the following classes: First, mucilage emulsions, of which the following is an example:

Cod-liver oil	50 parts.
Oil of wintergreen	2 "
Mucilage of tragacanth	15 "
Water of orange flowers, sufficient to make	100 "

A little "knack" is required to make it well. The mucilage is the emulsifying agent, and the oil should be added to it very slowly, and *most thoroughly stirred until it is divided into invisible particles*, before the water is added. The oil of wintergreen is only a flavor, which may be varied to suit. This makes a good, permanent mixture of about the consistence and appearance of thick cream. Instead of tragacanth, mucilage of acacia, about twice the amount, or a decoction of Irish moss, may be used.

Second, egg emulsions: These are made like salad dressings, by using the yolk of egg as the suspending ingredient. The following is a good one:

Cod-liver oil	50 parts.
Oil of sassafras	3 "
Chloroform	2 "
Glycerite of yolk of egg	10 "
Rose water, enough to make	100 "

Here the oil and the egg must first be "emulsified," when the other ingredients may be added—the water last. This is a thinner liquid than the preceding.

The pancreatic emulsions are nominally made by emulsifying with pancreatin, and are theoretically the most perfect of all, but are practically attended with some difficulty; the ordinary "pancreatin" of the shops will not make a good result, and of those claimed to be so produced some are made by means of added alkalies, others by the fresh pancreas itself, and some do not even contain any cod-liver oil at all. Considerable care has to be exercised with all proprietary preparations, to see that the percentage of oil is not deficient, as the drawing out of the oil is a favorite method of rendering the preparation palatable. An ounce or two of perfectly sweet pancreas, chopped fine and mixed thoroughly with a gallon of oil, will, it is said, suffice, when the oil is filtered off and mixed with water, to emulsify it perfectly. Like the other emulsions, it can be flavored to taste. Iodine, iron, the hypophosphites, and other suitable additions can be made to all of them, but alcohol and tinctures are incompatible with the mucilaginous ones. If the patient would chew a bit of raw smoked herring before taking the oil, its taste would not be noticed.

The "wines," and similar preparations, of cod-liver oil, under whatever fanciful names, are utterly unreliable and are to be classed as unscientific.

Morrhuol is an alcoholic extract of the oil. Very little is yielded by fresh sweet oils, and the yield increases with the degree of putridity of the article. It is therefore to be regarded as essentially a putrefactive product, and whatever useful properties it may claim to possess, it need not be used for the effects of the oil.

Cod-liver oil is often given by inunction, with benefit, especially to marasmic babies. *W. P. Bolles.*

CŒLOM, COMPARATIVE DEVELOPMENT OF THE.—In all vertebrates the primitive intestine forms two sets of diverticula which are destined to become permanent tissues, (1) one toward the medullary groove which forms the chorda dorsalis, and (2) two lateral diverticula which form the body cavities. These latter are later on subdivided into pleural, pericardial, peritoneal, and other cavities. A detailed description of the theory of the formation may be found in Balfour's work, in Hertwig's "Embryologie," and in Minot's "Human Embryology."

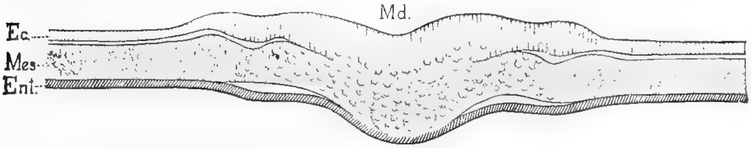

FIG. 1390.—Transverse Section through the Posterior Region of a Chick, with Six Pairs of Myotomes. (After Waldeyer, from Minot.) *Ec.*, ectoderm; *Mes.*, mesoderm; *Ent.*, entoderm; *Md.*, medullary groove.

When sections are made through very young embryos of higher vertebrates, just after the blastodermic membranes are well formed, a solid mesoderm is found, as shown in Fig. 1390. Although in lower vertebrates the mesoderm is produced by lateral diverticula from the entoderm, which are hollow from the beginning, in higher vertebrates the mesoderm is first laid down as a solid mass of cells. Soon the cells of the mesoderm on either side of the chorda divide into two layers, the somatopleure and the splanchnopleure (Fig. 1391, *Som.* and *Spl.*). From the two lateral cavities between these two layers the peritoneal cavity is formed.

The more accurate early formation of the pleuro-peritoneal cavity, in its relation to the other organs, we find carefully studied by Budge, who by means of injection followed it in the chick. With a fine hypodermic syringe he filled the various spaces of the cœlom as they appeared, thus showing very clearly the extent of this cavity in various embryos. The splanchnopleure, according to Budge, may be split into two layers, a dorsal or lymphatic and a ventral or vascular. As the first blood-vessels are formed, lymph vessels appear on their dorsal side, which flow together to form networks and accompany the primitive veins to the axial part of the germinal area. Here the lymphatics form two spaces, one on either side of the body, which are soon united by a bridge, or rather duct, on the ventral side of the heart. Therefore, in birds at least, the primitive pleuro-peritoneal cavity appears somewhat as an **H**, the uprights of which are on either side of the body, and the cross-piece on the oral side of the sinus venosus. In its further development the sinus venosus grows to the dorsal side of the cross piece, thus reversing the relation of the vascular system to the lymphatic, or rather cœlomic system. The uprights of the **H** fall to the outside of the body and are swallowed up in the formation of the amnion. Fig. 1392 is a cross-section from a chick at this stage, and shows that the greater portion of the cavity is now on the outside of the body. The cross-piece of the **H** is immediately on the ventral side of the heart, and forms the cavity of the pericardium by the heart growing into it. Its communication with the remaining cœlomic cavity is later on cut off in higher vertebrates, while in lower veretebrates it may remain open.

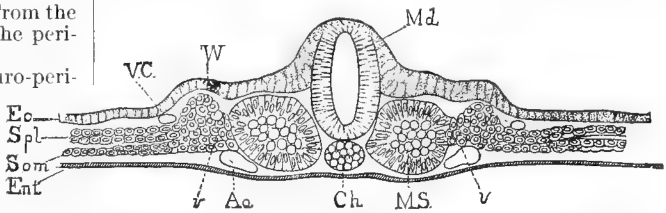

FIG. 1391.—Transverse Section of a Chick of the Second Day. (After Waldeyer, from Minot.) *Som.*, Somatic mesoderm; *Spl.*, splanchnic mesoderm; *Ec.*, ectoderm; *Ent.*, entoderm; *V.C.*, vein; *W.*, Wolffian duct; *Md.*, medullary canal; *Ao.*, aorta; *Ch.*, chorda; *M.S.*, myotome.

According to Budge two diverticula grow from the cross-piece, one on either side of the chorda, toward the tail of the body, and form the primitive pleuro-peritoneal cavities. Budge's paper was published from fragmentary notes after his death, and I am certain that the above statement is not correct. Professor His has placed before me Budge's specimens, which I think show conclusively that the interpretation of his injections is not correct. Most of his injections were made into the amniotic fold as the amnion was forming. Cross-sections of embryos show that on either side there is a large cavity (Fig. 1392, *Som.*) which communicates freely with the pleuro-peritoneal (*Coe*). Before the amnion is complete we have lateral cavities on either side of the body, communicating with each other only by means of the cross-piece on the ventral side of the heart. This is the freest portion of the communication, which also communicates most freely with the pleuro-peritoneal cavities

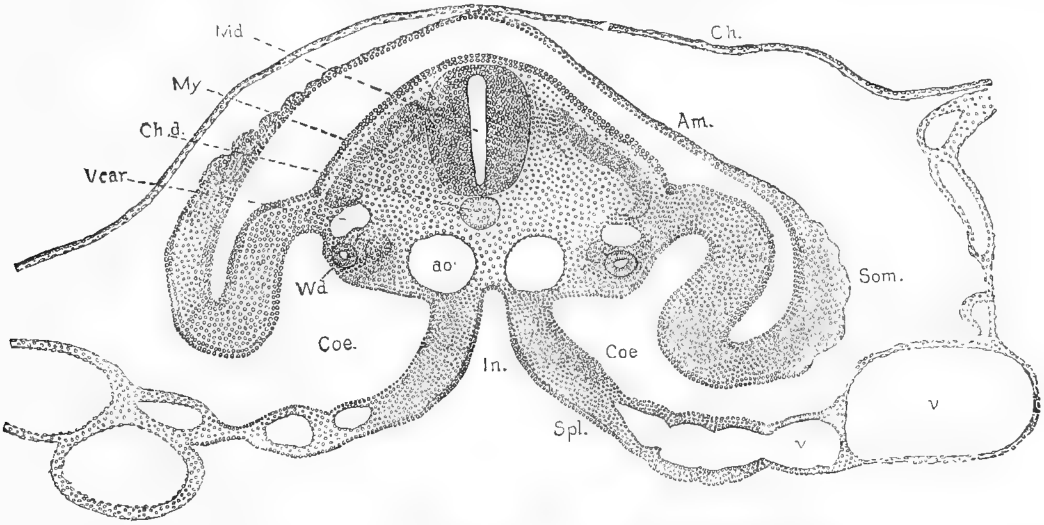

FIG. 1392.—Section through the Body of a Chick of the Third Day. (After Minot.) *Ch.*, Chorion; *Am.*, amnion; *Som.*, somatopleure; *v.*, blood-vessels; *Coe.*, cœlom; *Spl.*, splanchnopleure; *In.*, intestine; *ao.*, aorta; *Wd.*, Wolffian duct; *Vcar.*, vena cardinalis; *Ch.d.*, chorda dorsalis; *My.*, myotome; *Md.*, medullary canal.

(Fig. 1392, *Coe*). In many embryos the injection passed from the cross-piece into the pleuro-peritoneal cavity and would not extend out into the amniotic portion of the cœlom, thus making it appear as if the pleuro-peritoneal cavities were, so to speak, diverticula projecting directly from the cross-piece or pericardial cavity. Transverse sections, however, give the picture of Fig. 1393. Surface views could not decide that these two cavities united directly, and these sections were no doubt made after the writing of the rough draft of his manuscript. Therefore, instead of stating that the two pleuro-peritoneal cavities arise as independent diverticula, we must say that they are pinched off from the cœlomic cavity after the amnion is formed.

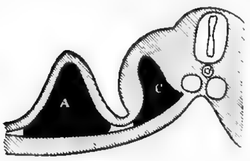

FIG. 1393.—Section of a Chick, to show that the Pleuro-peritoneal Cavity is cut off of the Cœlomic, leaving a Portion in the Amnion. The embryo has been injected, but the fluid of the two cavities has not flowed together.

The cœlomic cavities which are so intimately united with the lymphatic system unite and again divide into sections, thus forming the various compartments of the visceral cavity of higher vertebrates. In all of the vertebrates the heart, as it is developing, hangs into the ventral transverse portion of the cavity, or the primitive pericardial cavity. This is shown diagrammatically in Figs. 1394, 1395, 1396, and 1397, *P.*

Figs. 1394 to 1397 show the very early condition of things; the cœlomic cavities are united by the cross-piece or the primitive pericardial cavity. The dotted lines (Fig. 1394) mark what portion of the cavity is taken up in the amnion (*A.P.*), while the remaining middle portion (*P.P.*) becomes the pleuro-peritoneal. Figs 1395, 1396 and 1397 show in succession the more advanced stages. In higher vertebrates the pericardial cavity is completely closed off from the pleuro-peritoneal, but in elasmobranch fishes a communication between them exists in the adult. The separation of the pericardial cavity from the pleuro-peritoneal is aided materially by the heart growing over to the ventral side of the body, as shown in Fig. 1398. Sections through various parts of the same embryo, from which Fig. 1398 is taken, are shown in Figs. 1399 to 1404. In none of these sections is the communication between the pericardial and pleural cavities shown, but sections nearer the head contain it.

A cast of the cœlomic cavity of this same embryo is given in Fig. 1405. There is only a slight communication between the pericardial cavity and the pleuro-peritoneal. The groove in the cast marked *M* indicates the position of the simple mesentery. Its relation to these organs is better shown in the sections (Figs. 1399 to 1404). Fig. 1406 represents a section through a chick at an earlier stage of development, in which the duct communicating between the pericardial and pleural cavities is cut longitudinally.

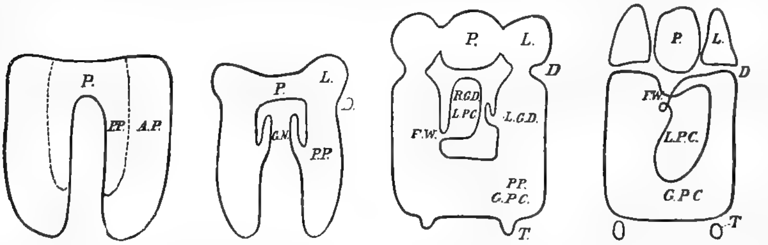

FIG. 1394. FIG. 1395. FIG. 1396. FIG. 1397.

FIGS. 1394, 1395, 1396, and 1397.—Diagrams to Show the Development of the Cœlomic Cavity. *P.P.*, Pleuro-peritoneal cavity; *A.P.*, portion of the cœlomic cavity swallowed up in the amnion; *P.*, pericardial cavity; *L.*, pleural cavity; *G.N.*, gastric diverticula, right and left; *D.*, position of the diaphragm; *L.G.D.*, left gastric diverticulum; *R.G.D.*, right gastric diverticulum or lesser peritoneal cavity; *F.W.*, foramen of Winslow; *G.P.C.*, greater peritoneal cavity; *T.*, tunica vaginalis.

Thus it is seen that the heart first grows into the primitive pericardial cavity, which is nothing else than the cross-piece of the **H** already spoken of. The pericardial cœlom grows larger and larger, at the same time hanging as it were over the ventral side of the body, and is soon connected with the pleuro-peritoneal cavity only by two ducts, which later on become closed in the higher vertebrates.

In early embryos the veins enter the heart behind, and not in front, as is the case in higher animals. The heart in its whole development undergoes a half-revolution, and in this way the twists, etc., are formed. Before the pericardial cavity is shut off from the pleuro-peritoneal the large vessels enter from behind. They are embedded in a mass of mesoblastic tissue which is encroaching upon the pleuro-peritoneal cavity, and has been termed by His the transverse septum. This, by its further growth, forms the diaphragm of higher animals (Figs. 1395, 1396, 1397). In lower animals only a rudimentary diaphragm, or none at all, is present. By the formation of the diaphragm the pleuro-peritoneal cavity is divided into a smaller anterior portion, the pleural, and a larger posterior portion, the peritoneal. The lungs now grow into the pleural, as shown in an early stage in Fig. 1406, and in a somewhat later stage in Fig. 1399.

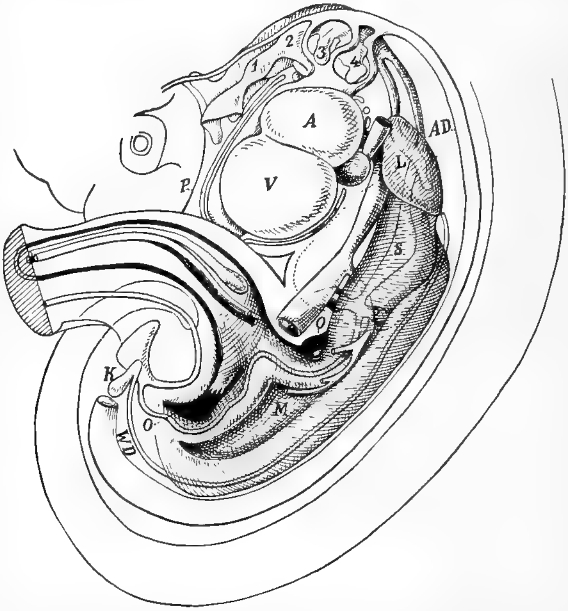

FIG. 1398.—Reconstruction of a Human Embryo. (Enlarged 16 times, viewed from the left side.) *P.*, Pericardial cavity; 1, 2, 3, and 4, branchial pockets; *A.D.*, descending aorta; *A.*, auricle; *V.*, ventricle; *L.*, lung; *S.*, stomach; *P.*, pancreas; *M.*, mesentery; *K.*, kidney; *W.D.*, Wolffian duct; *O.*, openings through which the right and left peritoneal cavities communicate.

The peritoneal cavity is at first composed of two distinct portions, one on either side of the intestine, which in lower animals is quite a straight tube, lying in the middle line of the body. Soon, however, two communications are found between the two halves, one in front and one behind the omphalo-mesenteric vessels (Fig. 1399, *O*). These openings enlarge more and more as the intestine becomes more convoluted, and soon flow together, severing completely the omphalo-mesenteric vessels and duct. A portion of the duct may, however, remain in connection with the small intestine to form the diverticulum of Meckel.

As the organs grow the peritoneal cavity surrounds them more or less completely, until the condition of things as seen in the adult is produced.

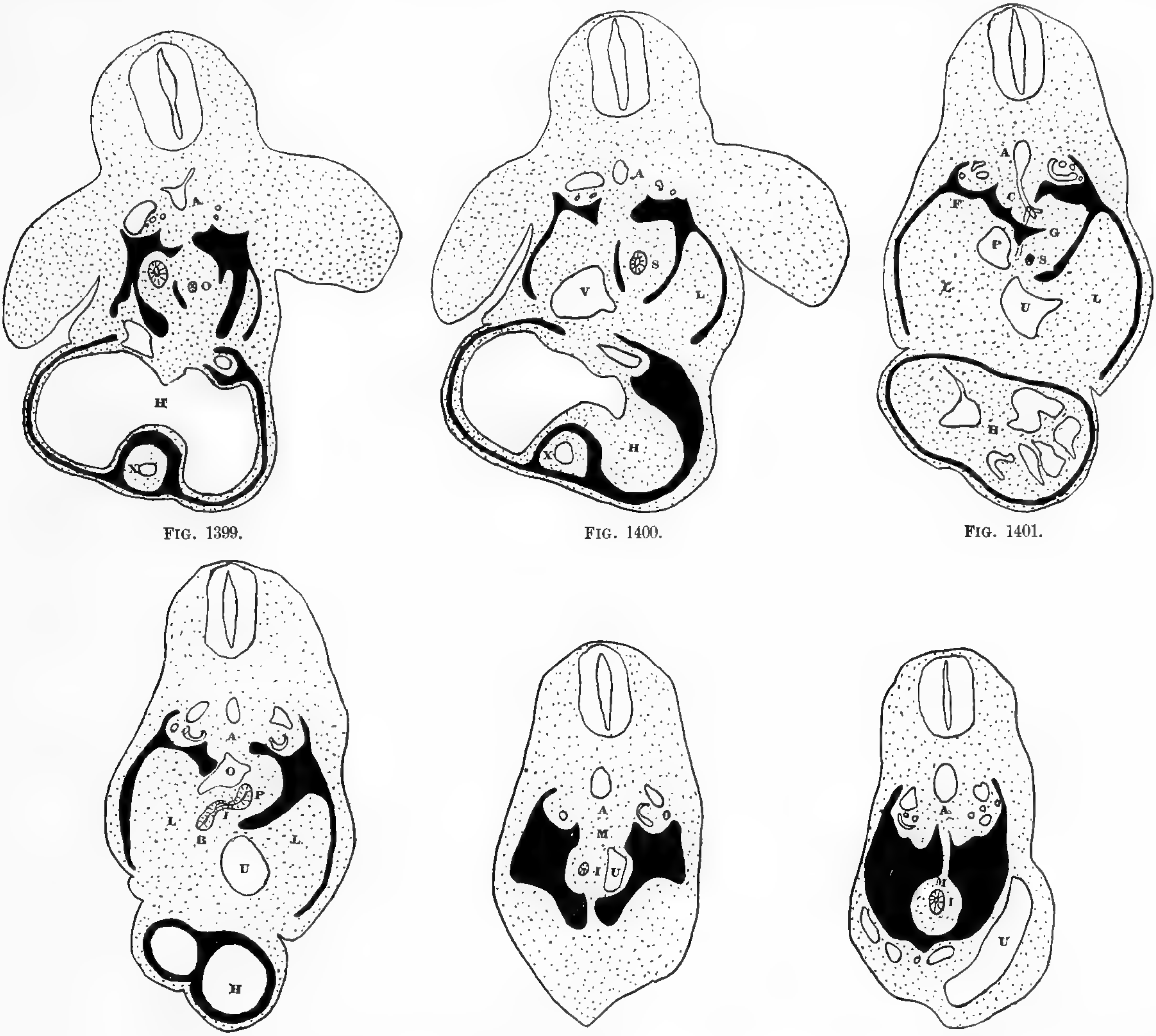

FIG. 1399.

FIG. 1400.

FIG. 1401.

FIG. 1402.

FIG. 1403.

FIG. 1404.

FIGS. 1399–1404.—Sections through a Human Embryo Twenty-six Days Old. (× 25 times.) *O.*, Œsophagus; *S.*, stomach; *I.*, intestine; *P.*, pancreas; *B.*, bile duct; *A.*, aorta; *C.*, cœliac axis; *G.*, right gastric diverticulum; *F.*, foramen of Winslow; *M.*, mesentery; *L.*, liver; *P.*, portal vein; *U.*, umbilical vein; *H.*, heart; *X.*, bulb of the aorta. The pleuro-peritoneal cavity is colored black throughout.

In lower vertebrates the peritoneal cavity remains quite simple, but in reptiles, birds, and mammals it may become quite complex. Especially is this true regarding the birds, in which these divisions are greatly complicated by the growth of the air sacs from the lungs.

The first trace of the lesser peritoneal cavity is seen in the reptiles. Ravn has shown that in the lizard there are two diverticula from the peritoneum, one on either side of the stomach. From the one on the right side the lesser peritoneal cavity of mammals arises. In general the relation of the lesser peritoneal cavity to the greater is much like what is shown in Fig. 1395. In the true sense of the term there is no lesser cavity, but only the two pouches. These are already present in the embryo, and in the adult they retain their embryonic appearance.

In birds the conditions become more complex. They appear in the chick during the third day of incubation. A section of the chick at this stage is given in Fig. 1406, *G.D.*, making the lesser cavities, or, as they may better be termed, the right and left gastric diverticula. At the beginning of the fourth day the gastric diverticula become larger, and on transverse section semicircular. Figs. 1407 and 1408 are from casts of the cavities about the stomach of a chick of eighty-eight hours. The right is larger than the left and is markedly cup-shaped, and connects by means of a narrowed opening with the right pleuro-peritoneal cavity (Fig. 1407, *F. W.*). The two together enclose the proventriculus. On account of the relations of the opening of the right diverticulum with the blood-vessels, stomach, and liver, and also for reasons which find their basis in comparative anatomy and embryology, the opening can be nothing else than the foramen of Winslow.

On the left side the gastric diverticulum is much smaller, and in older embryos it disappears altogether.

In a chick of five days and sixteen hours (Fig. 1409) the right gastric diverticulum has about doubled all its dimensions, while the embryonic foramen of Winslow has become much more sharply defined. At this time the liver has greatly increased in size, the right lobe being larger than the left, both lying anterior to the foramen of Winslow. The original position of the liver being behind the foramen, its rotation necessarily carries the hepatic artery and the portal vein around the foramen of Winslow—its adult position. With the growth of the gizzard a space extends from behind the right gastric diverticulum along the dorsal side of this organ, and marks the beginning of the cavity of the great omentum (*O.*). Nearly the whole of the right diverticulum now lies on the left side of the body; the same position is held by the proventriculus and the gizzard.

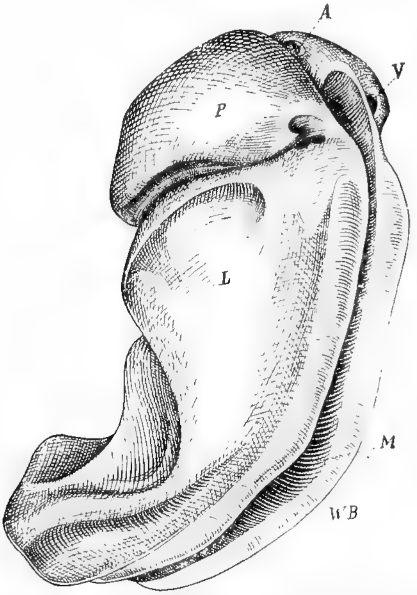

FIG. 1405.—Corrosion Preparation of the Pleuro-peritoneal Cavity of an Embryo Twenty-six Days Old. (× 22 times.) *P.*, Pericardial cavity; *A.*, opening for the aorta; *V.*, opening for the vein; *L.*, space over the liver; *M.*, slit for mesentery; *W.B.*, space for Wolffian body.

The domestic fowl possesses three peritoneal cavities, completely separated from one another, and from one of them the lesser cavity arises. The communication is by means of the foramen of Winslow. After the anterior abdominal walls are removed, two ventral cavities are exposed, separated from each other by a vertical longitudinal septum. Into each of the cavities hangs a lobe of the liver, while into the left the ventral surface of the gizzard projects. On the dorsal side of the liver there are, on each side, three air sacs — an anterior, a middle, and a posterior. The middle one is the smallest, and the posterior the largest, extending as it does throughout the posterior portion of the abdominal cavity. Each sac communicates by means of a special opening directly into the lungs. By allowing the sacs to collapse we find that a very distinct membrane projects backward from the gizzard and cuts off the portion of the abdominal cavity containing the intestines. This is the "pseudo-epiploön" described by Weldon and followed more extensively by Bedderd. A similar membrane is present in the crocodile. In all respects, this membrane is situated in the same position as is the epiploön in mammals, with the difference that it is adherent to the abdominal walls along its free border. On the dorsal side of the gizzard the air sacs fill all the space, thus closing off the communication between the cavity in which the intestines lie and the ventral cavities.

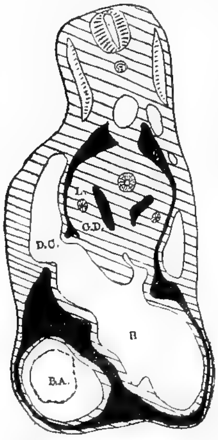

FIG. 1406.—Section through the Region of the Heart of a Chick of Seventy Hours. (× 35 times.) The section strikes the oral end of the gastric diverticulum *G.D.*, and the tips of the pulmonary buds, *L.* A few sections deeper the gastric diverticula communicate with the pleuro-peritoneal cavity. *H.*, heart; *D.C.*, ductus Cuvieri; *B.A.*, bulbus aortæ.

When the anterior and middle air sacs on the right side are separated from the posterior sac on the same side, a slit is shown which extends anterior and dorsal to the hepatic veins. Here it communicates by means of a round opening, about 1 cm. in diameter, with a large cavity lying on the median and dorsal side of the proventriculus and extending to the spleen. The cavity does not extend on the dorsal side of the gizzard. In all respects it corresponds with the right gastric diverticulum of embryos and with the lesser peritoneal cavity of mammals.

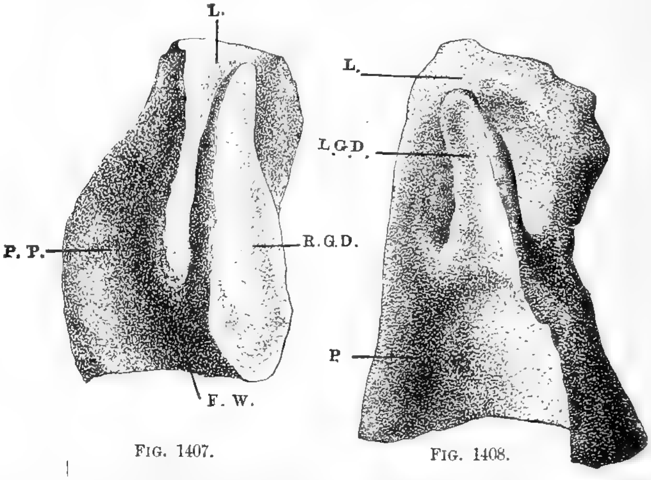

FIG. 1407. FIG. 1408.

FIGS. 1407 and 1408.—Corrosion Preparations of the Right and Left Gastric Diverticula of a Chick Eighty-eight Hours Old. (× 33 times.) *P.P.*, Pleuro-peritoneal cavity; *R.G.D.*, right gastric diverticulum; *L.G.D.*, left gastric diverticulum; *L.*, position of lung; *F.W.*, foramen of Winslow.

The relation of the embryonic omentum with the "pseudo-epiploön" is as yet unknown. However, I think it probable that the one is changed into the other, and that the "pseudo-epiploön" will prove to be the true epiploön homologous with the same in mammals. We

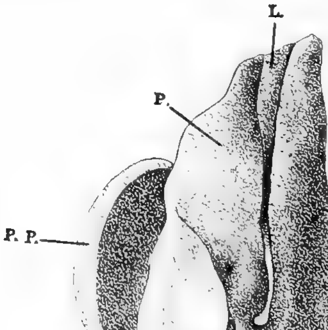

FIG. 1409. Corrosion Preparation of the Right Gastric Diverticulum from a Chick of One Hundred and Thirty-six Hours. (× 15 times.) *P.P.*, Pleuro-peritoneal cavity; *F.W.*, foramen of Winslow; *L.*, position of right lung; *P.*, position of proventriculus; *O.*, omental cavity (position of gizzard).

must imagine only the embryonic omentum attaching itself on the sides of the abdomen followed by a loss of the epiploönic cavity. A subsequent growth of the air sacs backward from the dorsal side of the stomach will produce the condition found in the adult.

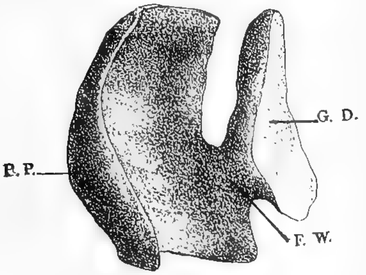

FIG. 1410.—Corrosion Preparation of the Gastric Diverticulum of a Human Embryo, 7 mm. long. (× 35 times.) *P.P.*, Pleuro-peritoneal cavity; *F.W.*, foramen of Winslow; *G.D.*, gastric diverticulum.

In mammalian embryos, while the stomach is still upright, only one gastric diverticulum is found. It is on the right side in Figs. 1399 to 1401, which are taken from a young human embryo. In each drawing the cœlomic cavity is colored black and the position of the section can be made out by the organs which are cut across in the section. A cast of the cavity is shown in Fig. 1405. The portion of the cavity on the right side of the stomach and the liver is shown in Fig. 1410, which is taken from a cast also. Figs. 1399, 1400, and 1401 show sections through the gastric diverticulum of Fig. 1410, Fig. 1401 being through the foramen of Winslow.

The general form of the cavities is shown in Fig. 1410, which is taken from a resconstruction of a human embryo. The peritoneal cavity surrounds the Wolffian body, intestine, omphalo-mesenteric vessels, stomach, liver, and lungs, with the addition of the right gastric diverticulum.

In lower mammals, according to Ravn, there are two diverticula; so the symmetrical arrangement of these cavities in reptiles, is still indicated in the mammals. It is so insignificant, however, that we need not take it into consideration.

The fate of the right gastric diverticulum of mammals has been studied in the dog, and it has been found that it is converted directly into the lesser peritoneal cavity, much as is shown in Figs. 1396 and 1397. In a dog's embryo, 6 mm. long, the diverticulum is much like what it is in the human embryo of about the same size (Fig. 1410). A dog embryo, 10 mm. long, shows a picture more advanced, much like what is seen in the chick of five days (Fig. 1409). In a later stage (Fig. 1411) the stomach has been twisted about, holding in great part the adult position. The liver, which before lay on the ventral side of the stomach, now lies in front, and to a great extent on the dorsal side of it. A model of these parts from a 10-mm. embryo, simply rotated to throw the stomach away from the mouth, gives the condition of things as they exist in the embryo 13 mm. long.

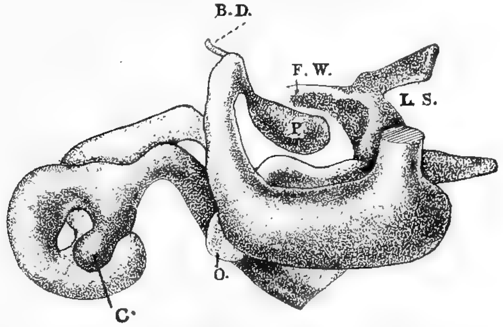

FIG. 1411.—Corrosion Preparation of the Stomach, Intestines, and Lesser Peritoneal Cavity of a Dog, 13.5 mm. Long, Viewed from the Left Side. (× 15 times.) The lesser peritoneal cavity has been filled with metal. *B.D.*, Bile duct; *P.*, *pancreas*; *C.*, cæcum; *O.*, omentum; *F.W.*, foramen of Winslow; *L.S.*, position of lobus Spigelii.

Fig. 1411 shows the lesser peritoneal cavity as a cast stuck in behind the stomach. The intestine is composed of two loops, one from the stomach, extending into the pelvis, and the other from the cæcum into the umbilical cord. The rapid growth of the large intestine has thrown the cæcum as high as the stomach and to the right of it. The fold of mesogastrium coming from the dorsal side of the stomach passes over the large intestine to form the omentum (Fig. 1411, *O.*). The general shape of the lesser peritoneal cavity is shown in transverse section in Fig. 1412, which can be compared with Fig. 1401. The **S**-shaped loop of intestine is cut across three times, and the lesser peritoneal cavity with the foramen of Winslow is shown throughout its whole extent.

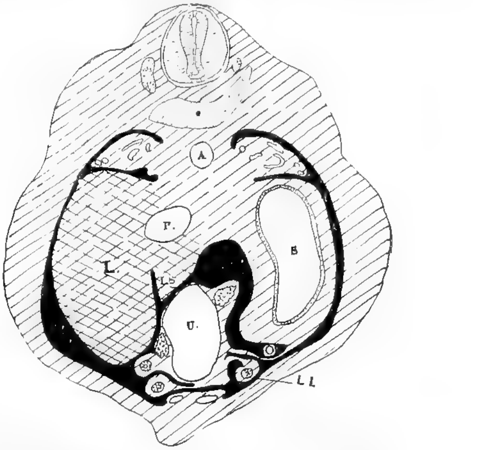

FIG. 1412.—Section through the Foramen of Winslow and Lobus Spigelii of a Dog, 13.5 mm. long. (× 36 times.) *A.*, Aorta; *S.*, stomach; *P.*, portal vein; *U.*, umbilical vein; *L.S.*, lobus Spigelii; *O.*, omental cavity; *L.I.*, large intestine.

The omentum from now on rapidly grows over the whole ventral wall of the abdominal cavity, and in man adheres to the colon as first described by Meckel.

A résumé of the comparative development of the cœlom of the embryo is given in Figs. 1394 to 1397.

Franklin P. Mall.

CŒLOM, HUMAN, DEVELOPMENT OF THE.—Unfortunately, there are no data regarding the beginning of the cœlom in the human embryo, and in all probability none will ever be found. The smallest human described until recently is that described by Reichert.[1] It was obtained from a woman who had committed suicide, on account of pregnancy, forty-one days after the beginning of the last menstrual period. It was therefore presumably about thirteen days old. This ovum, which is pictured in every text-book, was 5.5 × 3.3 mm. in diameter, was surrounded by a zone of villi leaving two poles bare, and contained in its interior a mass of cells measuring 1.5 × 1.75 mm. All the space between this inner mass and the chorion is the cœlom, and regarding its origin we can no more than speculate.

During the last few years five other human ova, about as large as Reichert's, have been cut into sections, thus permitting a more careful study of their contents.[2] The dimensions and approximate ages of these embryos are given in the table in the first column of the following page.

It is noticeable that in the embryos just mentioned the size of the whole egg does not correspond with the size of the embryo, nor with its age. I do not think that this great variation in the size of the chorionic vesicle is altogether due to the method of hardening the specimen. Just at this time the growth of the chorion is precocious, as is also the case in the dog,[3] rabbit,[4] and monkey [5]

The papers by Bischoff and by Selenka are worthy of the most careful study by every embryologist, and I take the liberty of rearranging some of Bischoff's data on the

TABLE OF YOUNG HUMAN OVA.

Observer.	Diameter of embryonic vesicle, millimetres.	Diameter of Ovum. millimetres.	Time between first lapsed period and abortion.
Peters	0.19 × ?	0.3 × 1.5	
Siegenbeek van Henkelom	.325 × ?	5.5 × 4.5	
Mall (No. XI.)	1.5 × 1.0	10 × 7	13 days.
Reichert	1.75 × 1.5	5.5 × 3.3	14 "
Von Spee (v. H.)	1.84 × 1.083	6 × 4.5	12* "
Von Spee (Gle.)	2 × 2	10 × 8.5	12* "
Mall (No. XII.)	2.1 × 2.1	18 × 8	13 "
His (Lg.)	2.15 × 2	15 × 12.5	12 "
Von Spee	2.69 × 3	15 × 14	14 "
Janosík	3 × 4	8	15 "

* These are all of the authentic young human ova I can collect from the literature giving all of their measurements as well as the menstrual history of the mother. In both of von Spee's cases the time between the abortion and the end of the last period is given; in embryo v. H. the time is given as "exactly five weeks," while in embryo Gle. "five weeks" is given. If we estimate the duration of menstruation as five days and its frequency twenty-eight days, then the time between the first lapsed period and the abortion is twelve days, as I have given it in the table.

development of the dog. His observations are very extensive, and give us the basis for our present ideas of the passage of the ovum into the uterine tube after fertilization. Unfortunately, they were made before the time of sectioning specimens, yet they are more complete than most researches relating to this subject published since his time.

The portion I tabulate relates to the size of the embryonic mass or vesicle, the size of the ovum, and its approximate age. As far as I have been able to determine, these data taken from the dog are still the most important ones with which we can compare the human ovum. Embryologists are accustomed to state that the age of a human ovum is to be reckoned from the beginning of the first lapsed period, and I think that Bischoff's observation upon the size and growth of the dog's ovum corroborates this view. He found that the ova left the ovary during the rutting period, but the exact date could never be determined. Neither did the time of copulation determine the ovulation. As a rule, it took twenty-four hours or less after copulation for the spermatozoa to reach the ovary, and about the same time is required for the ovum to reach the beginning of the uterine tube after ovulation. So if ovulation and copulation took place at the same time, fertilization of the ovum could not take place until twenty-four hours later.

Bischoff in his tables often rates the age of an ovum from the first or from the last copulation, or from the beginning or from the end of the rutting period. I have attempted to tabulate his specimens from all four of these dates, but in none of the attempts did the size of the ova correspond with their respective dates. Often eggs of a given date were smaller and developed to a less degree than ova presumably younger. After much difficulty I finally constructed a table in which the size of the ovum and its age correspond. A number of the ova published by Bischoff were obtained from the same animal by removing half of the uterus at one time and the remaining half the next day. In each half a number of ova were found, and they were usually of about the same stage of development. By this method of procedure it is possible to determine very accurately the growth of the ovum from one stage to one twenty-four hours later. So, by gradually plodding through the specimens published by Bischoff, it was possible for me to correct his data completely. It is remarkable, as the table shows, how slowly the development takes place in the early stages, and about ten days are required before the ovum is 1 mm. in diameter. On the fifteenth or sixteenth day the ovum is about as large as the human ovum described by Reichert (see table).

Similar results can also be obtained from the various papers published on the rabbit's embryo. Its development, however, is considerably more rapid than the dog's as the period of gestation is but thirty days.

TABLE OF AGE AND SIZE OF THE DOG'S OVUM.
(Compiled from Bishoff.)

Age.	Diameter of ovum, millimetres.	Diameter of embryonic mass, millimetres.	Stage.
1 day	0.15	....	1 cell.
2 days	.14	....	2 cells.
3 "	.14	....	4 "
4 "	.16	....	12 "
5 "	.16	....	64 "
6 "	.18	....	Mulberry.
7 "	.20	....	"
8 "	.21	....	"
9 "	.28	....	"
10 "	.30	.07	
11 "	1.	.16	
12 "	2.	.24	
13 "	3.	.43	
14 "	4.	.5	
15 "	5.	1.	
16 "	5.	2.	
16½ "	6.	3.	

It has been somewhat difficult to compile this table, as Bischoff's measurements are all given in Paris lines. My measurements are taken in great part from his figures, and I think that these are very accurate.

Recently Selenka has given some of his results relating to the development of the monkey. The most valuable specimen relating to the early development of higher animals was unfortunately lost, but its age and dimensions are preserved for us, and are of value in the determination of the age of human ova. The ovum came from a monkey kept in confinement which was killed eight days after copulation. If we estimate one or two days required before fertilization, this ovum cannot be over seven days old. This suggests that the early stage of this variety of monkey is developed more rapidly than that of the dog.

DEVELOPMENT OF THE MONKEY.

	Diameter of ovum, millimetres.	Diameter of embryonic vesicle, millimetres.
Semnopithecus maurus	1.5	0.3 *
Semnopithecus pruinosus	6	.5
Cercocebus cynomolgus	5	.5
Cercocebus cynomolgus	10	2.4 †

The pictures Selenka gives indicate that the development of a monkey's ovum is identical with that of the human ovum. At any rate, the few specimens Selenka publishes give results which are equal to the great number of specimens of human ova which have been published. This only indicates that many of the interesting problems relating to early human development will probably be solved by the study of the monkey's ovum. There is but little doubt now that young monkeys' ova will soon be obtained for study.

* Not an embryonic vesicle, but only a disc.
† Neurenteric canal present.

MATERIAL EMPLOYED.

During the last few years I have obtained a number of young human embryos from physicians in different portions of the United States, and to them I am under all obligation for the present study as well as for some others which are to follow. Nearly all of the specimens which I give in a table are well preserved, and a number of them are preserved excellently. All of the specimens were stained in alum carmine, and with the exception of Nos. XVII., XLIII., and LVII. were cut transversely. These three were cut into sagittal sections.

All of the specimens were hardened in alcohol, the value of which method I have repeatedly emphasized to my friends, and do continue to emphasize to those who may preserve specimens for my use in the future.*

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* Embryologists usually recommended that human embryos should be hardened by placing them in dilute alcohol and then gradually increasing the strength of the alcohol. It has been my experience that by this treatment the specimen is injured by maceration due to the

List of Embryos Studied.

No.	Length of Millimetres.		From whom obtained.
	V. B.*	N. B.	
XI	....	....	Dr. Kittredge, Nashua, N. H.
XII	2.1	....	Dr. Ellis, Elkton, Md.
III	2.2	....	Prof. His, Leipsic, Germany.
XIX	5.	4.5	Dr. Williams, Baltimore, Md.
XVIII	7	7	Dr. Douglas, Nashville, Tenn.
II	3	7	Dr. C. O. Miller, Baltimore, Md.
IV	....	7	Dr. Williams, Baltimore, Md.
XLIII	15	13	Dr. Booker, Baltimore, Md.
VIII	17	14	Dr. Ritter, Brooklyn, N. Y.
IX	17	14	Dr. Eycleshymer, Chicago, Ill.
V	18	17	Dr. Kittredge, Nashua, N. H.
XLII	18	15	Dr. Wills, Los Angeles, Cal.
XVII	18	16	Dr. Cottrell, Louisville, Ky.
XXVIII	19	18	Dr. Sewall, Denver, Col.
VII	19.5	18	Dr. Booker, Baltimore, Md.
XXII	20	18	Dr. Snively, Waynesboro, Penn,
LVII	23	20	Dr. Howard, Cleveland, Ohio.
VI	24	....	Dr. C. O. Miller, Baltimore, Md.
X	24	20	Dr. W. S. Miller, Madison, Wis.
XLV	28	19	Dr. Douglas, Nashville, Tenn.
XXXIV	80	60	Dr. Ellis, Elkton, Md.
XLVIII	130	110	Dr. Wilson, Worcester, Mass.

* V. B. and N. B. indicate the length of the embryo measured from the vertex to the breech and from the nape of the neck to the breech, respectively.

Nearly all of the embryos were drawn or photographed to scale and then carefully cut into sections from 10 to 50 μ thick. I find that for purposes of reconstruction it is a mistake to cut the sections very thin. Yet in small specimens, as Nos. XI. and XII., the specimens were cut thin to permit of careful cytological studies also. In most of the specimens photographs or an additional series of sections were made of the chorion and amnion in order to study the variation of these structures.

Embryos XI.,[6] XII., and II.[7] were completely reconstructed in wax by the method of Born. Nos. IX., VI., and X. were reconstructed in part by Born's method and finished by His's method of reconstruction. The abdominal viscera of Nos. VI., IX., X., XXXIV., XLV., and XLVIII. were modelled by Born's method.[8]

The mechanical portion of reconstruction has been simplified to a great extent by a special apparatus used in the Anatomical Laboratory,[9] which enables us to employ a modeller. The sections are projected upon a screen, to which the wax plate is attached. By working in a dark room with this apparatus it is easy to direct a modeller to draw the outlines accurately. He can then cut them out, and all that remains to be done is to pile the pieces and then blend them.

The Cœlom in Young Ova.

All of the young human ova which have been described contain within them a cavity, lined with mesoderm; this is the cœlom, bounded by the somatopleure on the outside and by the splanchnopleure on the inside. This arrangement, as shown by a number of diagrams by recent authors, is very unlike the appearance of the blastodermic membranes of many of the lower mammals, and it is necessary, therefore, that we should revise our conception of the formation of the amnion in the human embryo.[10]

The ova recently published by Peters and by Graf Spee indicate that the amnion must be formed very early, and, since it is completed before the medullary grooves begin, we must admit now that it is formed much the same as it is in many rodents, *i.e.*, by apparent inversion of the membrane. When Bischoff[11] first described inversion of the membrane in guinea-pigs it seemed like a paradox, but, since the comparative methods of study have been introduced, inversion only means that the amnion is completed before the medullary groove begins to form. This alteration of the development of the amnion and the medullary groove makes the body of the embryo develop on a concave surface instead of on a convex one, thus apparently making the embryo inverted, as is the case in the guinea-pig.

Closely associated with inversion of the blastodermic membrane is the formation of an additional layer of cells, discovered by Rauber,[12] the importance of which has been emphasized by Selenka and others. Rauber's layer is so marked in the rabbit that it was at first believed to be the true ectoderm. The fate of Rauber's layer has not been sufficiently studied to interpret it completely, and our ideas regarding it will not improbably require some revision. In many rodents Rauber's layer becomes markedly thickened on one side of the ovum, forming a support, or *Träger*, for the ovum. The relation of Rauber's layer to the *Träger* is shown beautifully by Selenka[13] on Plate XVI. of his monograph.

The question which interests us here is whether the inversion of the blastodermic membrane as well as the discovery of Rauber's layer aids us in advancing a theory of the development of the germ layers of the human embryo, and thus in turn to explain the large cœlom as found in all of the earliest human ova. I realize fully that any such effort will not be final, yet I believe that it will aid us to understand better the relation of the membranes as found in the human ovum.

In looking over the illustrations of the development of animals closely related to man, one is struck with the similarity of the arrangement of the membranes to those described for the human ovum by Peters and by Graf Spee. One must compare only plates XXXV.–XXXVIII. of Selenka's[14] paper with the two plates accompanying Graf Spee's[15] to be convinced that the early development of monkeys is almost identical with that of man. Yet Selenka's researches on monkeys do not help us a great deal; they only show us that the monkey's development is like that of man. In monkeys we have also the precocious chorion and the early amnion and the large cœlom between the umbilical vesicle and the chorion. The marked difference is that the amnion is attached to the chorion along its dorsal side, while in the human embryo this is only the case along the posterior end of the amnion. The attachment of the amnion along the chorion suggests that the embryonic plate separated from the exterior of the ovum along this point, as Selenka thinks he observed in a very young ovum only 1.5 mm. in diameter. Unfortunately, the most valuable specimen was injured in its preparation,[16] and Selenka did not trust himself to give any illustrations of it.

With the amnion attached at its dorsal end to the chorion, we understand why the entodermal end of the allantois must grow around an angle to reach the chorion (Selenka, Plate XXXVII., Fig. 5). Somewhat the same arrangement has been described by Graf Spee[17] in his embryo Glc., but the curve is by no means as marked, indicating that the attachment of the embryo to the chorion is along its posterior end, as shown by His[18] in his well-known diagram of the formation of the amnion.

Regarding the very early stages of monkeys and man it is better that we make comparisons with animals most nearly related to them, and now we have careful studies of the very early stages of Chiroptera at our disposal. I believe that Selenka's[19] study of the development of Pteropus edulis gives us the key for the comparison of the formation of the blastodermic membranes in mam-

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weak alcohol. A few years ago I emphasized the fact that the whole ovum should be placed in a large quantity of strong alcohol as soon as possible. It should be handled as little as possible before hardening it, thus preventing mechanical injury. By leaving the ovum closed the alcohol must first penetrate the chorionic and amniotic fluids before it reaches the embryo, and thus, without placing the embryo first in weak alcohol, it naturally passes through the successive dilutions of alcohol before it is completely hardened.

It is very injurious to these delicate specimens to be wrapped in cotton before they are sent by mail or express. A perfect method is to place the preserved specimen in a bottle filled completely with alcohol, thus imitating the condition of a *fœtus in utero*. If there is no air or cotton in the bottle containing the embryo it is almost impossible to injure the embryo by shaking it.

Since I have emphasized this method of preparation (Johns Hopkins Hospital Bulletin, 1893), I have obtained a number of specimens excellent in every respect. These specimens are not distorted, nor macerated, nor shrunken.

mals. Recent investigations by Duval[20] on different families of Chiroptera appear to confirm the work of Selenka on Pteropus.

In order to illustrate these points more clearly I have made diagrams of three of Selenka's figures of Pteropus.

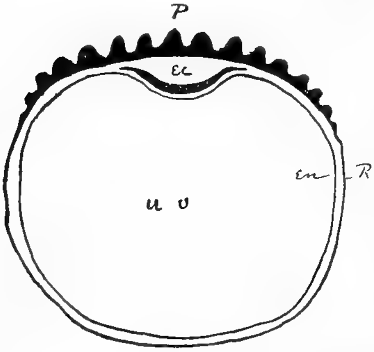

FIG. 1413.

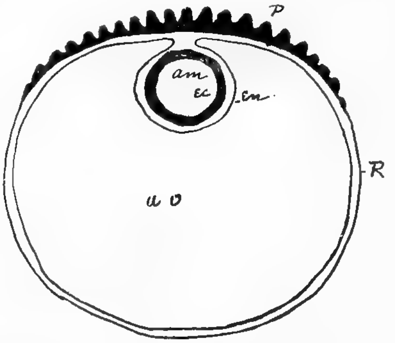

FIG. 1414.

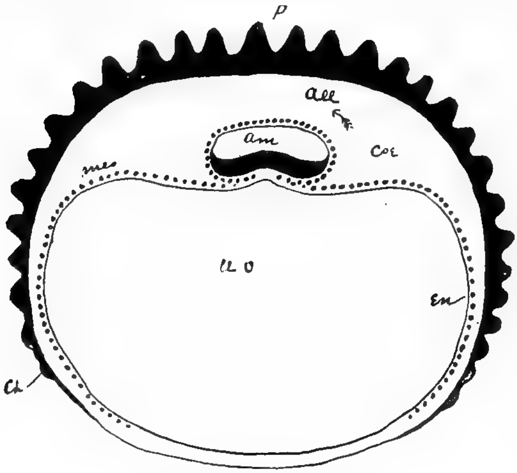

FIG. 1415.

FIGS. 1413-1415.—Diagrams of the Development of Pteropus Edulis, after Selenka. Fig. 1413 is Selenka's Fig. 2; Fig. 1414, Selenka's Fig. 5; Fig. 1415, Selenka's Fig. 9. *R*, Rauber's layer; *P*, placenta; *ec*, ectoderm; *en*, entoderm; *ch*, chorion; *am*, amnion; *u v*, umbilical vesicle; *mes*, mesoderm; *coe*, cœlom; *all*, allantois, with the arrow indicating the direction of its future development.

Fig. 1413 is from an ovum covered completely with two layers of cells, between which at one pole of the egg there is a mass of scattered cells destined to become the permanent ectoderm. The outer layer of cells has a tendency to grow into the form of villi over the embryonic disc, while on the opposite side of the egg it is composed of but a single layer of cells. Since this outer layer remains well separated from the body of the embryo throughout its development, and since it holds the same position to the egg that Rauber's layer does in the rodents, I believe it to be identical with Rauber's layer, and shall speak of it as such. According to Duval this Rauber's layer disappears over the embryonic disc in the Chiroptera much as in the development of the rabbit and the field mouse. This does not necessarily contradict Selenka's observations on Pteropus, for the house mouse begins to develop like the field mouse, but continues during the early stages in the same manner as Pteropus does.

In the next stage the ectoderm has been converted into a hollow mass of cells, Fig. 1414, rather by a process of absorption than by an invagination, as I have expressed it in the diagram. The entoderm lines the whole interior of the egg, and surrounds the ectoderm of the amniotic cavity. The ectoderm of the exterior of the egg, Rauber's layer, is again thickened over the embryonic mass to form the placenta, as Selenka calls it, or the *Träger*, if we were discussing rodent embryology.

In the next stage, as expressed in Fig. 1415, the mesoderm is beginning to form, and has extended completely over the amnion and partly over the umbilical vesicle. The entoderm has retracted itself and touches the ectoderm; only the chorda dorsalis is yet to form. Between the amnion and the placenta, or the *Träger* portion of Rauber's layer, there is a marked space, and the mesoderm does not come in contact with it. The allantois grows as a bag into this space and attaches itself to the thickened part of the ectoderm, as shown by Göhre[21] in his figures. In the Fig. 3 accompanying Göhre's paper he shows the vesicular allantois attached to the support of the chorion (black portion of my Fig. 1415) leaving on either side of the embryo a cœlom. The allantois carries the mesoderm and vessels to the villi of the chorion, and these in turn are embedded in the decidua of the uterus. In so doing the ectoderm of the chorion receives a second layer of epithelium, and I believe that this must account for the two layers of epithelium we have on the chorionic villi of the human ovum. There has been much written on the subject of the double layer of epithelial cells of the human chorion, and I think that a glance at Göhre's Figs. 3 and 4, on Pteropus, as well as at Selenka's Figs. 11 and 12 (Plate XXXV.) and Fig. 6 (Plate XXXVII.) on monkeys, will decide this question more definitely than all the many discussions on the human chorion put together have done.

Having now selected from Selenka diagrams and descriptions of the development of the germ layers of Pteropus, it is easier for me to give a plausible explana-

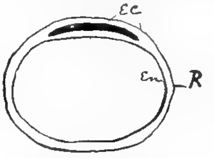

FIG. 1416.

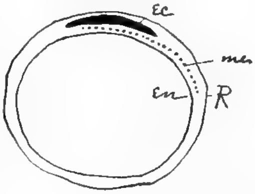

FIG. 1417.

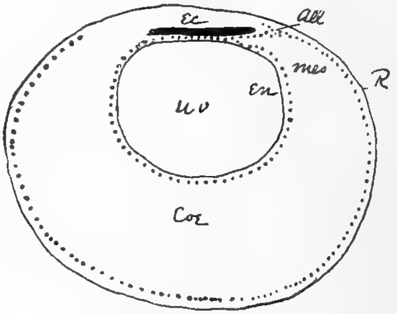

FIG. 1418.

FIGS. 1416 to 1418.—Hypothetical Stages of the Early Development of the Human Ovum. *R*, Rauber's layer; *ec*, ectoderm; *en*, entoderm; *mes*, mesoderm; *uv*, umbilical vesicle; *coe*, cœlom; *all*, position of allantois.

tion of the beginning of the cœlom in the human embryo. If the diagram I have given in Fig. 1415 is compared with Selenka's Figs. 5 and 11 (Plate XXXV.) and Fig. 5 (Plate XXXVII.) of the monkey, as well as with the sections of young human ova published by Graf Spee[22] and by myself,[23] one is struck with the great similarity of the two groups of figures.

Fig. 1426, given further on, is a diagrammatic outline of a longitudinal section of a young human embryo published recently by Graf Spee. It is the one marked v. H. in the table of young human ova given in the beginning of this paper. When, now, this section is compared with the transverse section of Pteropus, in Fig. 1415, the only marked difference is that the umbilical vesicle in Pteropus has retracted, in order to make the arrangement of the membranes as given for the human embryo in Fig. 1426.

In order to make the connection complete, I give hypothetical stages in Figs. 1416, 1417, and 1418. Fig. 1416 represents the human ovum in the two-layer stage. The outer layer, or Rauber's layer, is complete as in the rodents and in Pteropus. The inner layer, or entoderm, is also complete. Between the two is the embryonic shield, or ectoderm of the future embryo. The next figure, 1417, shows the beginning of the mesoderm developing toward the tail end of the embryo, as this is the position of the primitive streak, and as the head fold of the amnion in many embryos is often invested only with ectoderm and entoderm. A stage later, Fig. 1418, finds the mesoderm enveloping the umbilical vesicle completely, and also partly lining the outer layer, *R*, of the ovum. The cavity between the two is the cœlom. At the tail end of the embryonic disc the mesoderm of the somatopleure and splanchnopleure are still united, and mark the place of the formation of the rudimentary allantois.

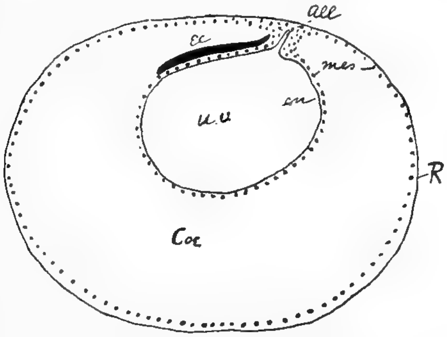

FIG. 1419.—Diagram of a Pathological Ovum which Represents an Early Hypothetical Stage.

Having carried the development of the human ovum to this stage by means of hypothetical stages, based upon the development of Pteropus, I can now continue the description of the development based upon observation.

Abnormal Ova.—Teratologists are accustomed to view a group of abnormal states as arrested development, and in recent years a number of abnormal human ova have been studied by His,[24] by Giacomini,[25] and others. Frequently in the development of an ovum the embryo is destroyed completely, or, according to Giacomini, may wander out of the ovum. In these cases the ova are aborted. Frequently, however, a portion of the embryo is not developed, or it dies and the remaining portion develops for a time, and then the ovum is aborted. I have now in my collection a beautiful example of an ovum of apparently normal structure, the interior of which is lined completely with an amnion, and in place of an embryo there is only an umbilical cord. The ovum was aborted fifty-four days after the first lapsed period, and was 30 mm. in diameter. The cord was 2 mm. in diameter and 9 mm. long. Its embryonic end seemed to be cut off abruptly, and was covered with a small mass of round cells. I give this example only to show that the embryo may be entirely wanting with a perfect cord and membranes.

TABLE OF VESICULAR FORMS OF PATHOLOGICAL EMBRYOS.

No.	Dimensions of		Time between last period and abortion.	
	Ovum.	Vesicle.		
XIII	8 × 7	1 × 6 × 6	......	Amnion formed.
CXXXIV ..	17 × 11	9 × 3	33 days.	Amnion partly formed
XI	10 × 7	1.5 × 1	41 "	" " "
LXXXVII	24 × 16 × 9	2.5	42 "	Partial amnion.
LVIII	20 × 18 × 12	6	71 "	" "
LXXVIII..	36 × 33 × 13	1 × 6	87 "	Multiple amnion.
XXIV	21 × 16 × 5	2.6	......	" "
XIV	30	1.5	......	No amnion.
CXXIII ...	17 × 14	2 × 1.5	27 days.	" "
XXI	40 × 30	5.5 × 3.5	......	" "
CXXX	15 × 10 × 6	4 × 3 × 1.5	14 days.	" "
CXLVII ...	30 × 27 × 20	1		" "
CXLIII ...	....	25 × 10		

A large per cent. of young ova which come into the embryologist's hands are abnormal. According to Professor His' experience over half of the ova less than three weeks old are abnormal, while of those of four and five weeks one-quarter are abnormal. In my collection the per cent. of abnormal embryos is not as high. No. XIII. is His' Embryo XLIV., which is frequently described in the books as a normal specimen, but which unfortunately is an abnormal one. My interpretations of the vesicular forms[26] is that the fibrous degeneration overtook the embryonic vesicle after it had reached the stage of Graf Spee's embryo v. H., my Fig. 1426.

Nos. XXI. and LVIII. came to me as perfect specimens both having been hardened unopened, the first in strong formalin and the second in strong alcohol. No. XXI. was still enclosed in its decidua, and appeared to be a normal specimen until it had been cut into serial sections. The embryonic vesicle proved to be very large, and was composed throughout of two layers, an inner one giving all the appearance of the entoderm and an outer giving all the appearance of the mesoderm of the umbilical vesicle of young embryos. The mesodermal layer contained within it islands of blood cells, as are also present in normal specimens. The whole vesicle was connected to the chorion with a mass of mesodermal cells somewhat as shown in the diagrammatic Fig. 1419. The chorion and decidua appeared to be normal.

No. LVIII. showed considerable change in the mesoderm of the vesicle and chorion, giving somewhat the appearance of fibroid degeneration rich in cells. The chorion was attached to the vesicle by a strong pedicle, as shown in Fig. 1419. The vesicle itself was composed of two layers, an inner and continuous one composed of one layer of cells, and an outer and thickened layer appearing like the mesoderm of the chorion. There were no indications of blood islands. In addition to these two layers there was a third layer fairly well marked near the pedicle and between the vesicle and the chorion. With the exception of the allantois canal, Fig. 1419 is a diagram of this specimen.

Giacomini[27] has described a number of similar vesicles, and he expressly states that the vesicles had the structure of the umbilical vesicle, but that there was no trace of the amnion present in any of them. A number of other vesicular forms have been described, and in general they all appear much like the two specimens I have given.

I do not think that it is rash to assert that these vesicles represent an arrested development of an earlier stage, which, due to impaired nutrition, or whatever it might have been, simply allowed the embryonic vesicle to keep on expanding. That this expansion can keep on is already shown in the simple enlargement of the chorion after the embryo is distorted or wanting altogether. We have in these specimens a thin chorion with atrophic villi, and why can we not have an expanded and atrophic embryonic vesicle if its development is impaired? In this way I view specimen No. LVIII. It represents a much earlier stage, which has simply expanded and was ultimately aborted. In No. LVIII. the embryonic vesicle must have ceased its further development a week or so before the abortion, about the time the cœlom was beginning to develop. At that time the fibrous degeneration enclosed the embryonic vesicle as well as extended around the whole chorion into all of its villi. This, then, arrested the further development of the embryo, and the embryonic vesicle simply continued to expand.

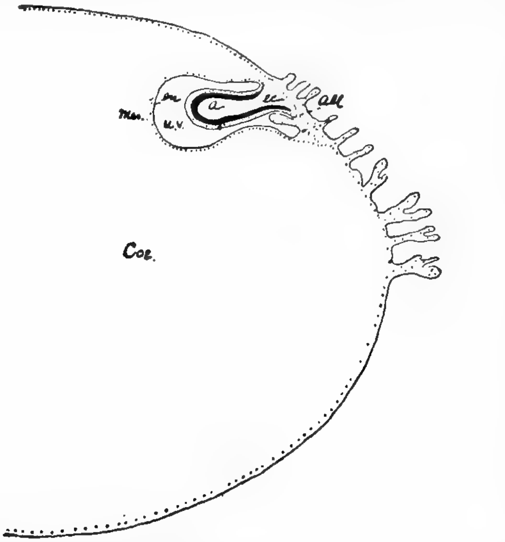

FIG. 1420.—Diagrammatic Section of Half of the Human Ovum No. XI. Enlarged 10 times. The villi are drawn only on the upper side. *ec*, Ectoderm; *en*, entoderm; *mes*, mesoderm; *uv*, umbilical vesicle; *coe*, cœlom; *all*, allantois; *a*, amnion.

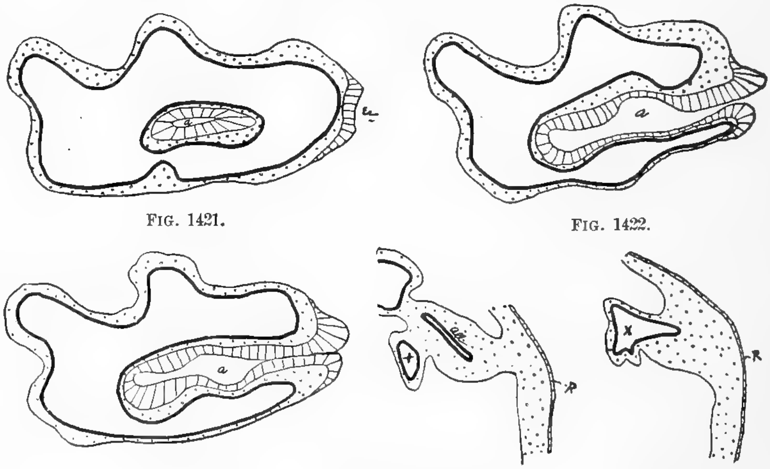

FIG. 1421. FIG. 1422. FIG. 1423. FIG. 1424. FIG. 1425.

FIGS. 1421-1425.—Sections Nos. 43, 53, 68, 80, and 89 through the Embryonic Vesicle of Embryo No. XI. Enlarged 33 times. The entoderm is a heavy line, the ectoderm is striated, and the mesoderm dotted. *a*, Amnion; *X*, cavity of the umbilical vesicle extending into the stem of the vesicle; *R*, Rauber's layer as the ectoderm of the chorion.

This idea is further strengthened by another ovum whose history I published on several occasions several years ago.[28] The specimen is a good one, having been preserved fairly well, and it has every indication of being normal. Since the specimen has been in my hands I have studied it over and over again, have photographed many of the sections, and have reconstructed it. At first it was very difficult for me to interpret it, but finally it appears to me that something definite can be said regarding the arrangement of the membranes and their relation to older as well as to the pathological and presumably younger specimens.*

Embryo No. XI.—"The woman, from whom the specimen was obtained, is twenty-five years old, menstruates regularly every four weeks, the periods lasting from four to five days. She gave birth to a child September 19th, 1892, and had the first recurrence of menstruation December 19th. The second period followed on January 25th, and was very profuse; it lasted until February 1st. The next period should have begun about February 22d, but on account of its lapsing the patient concluded that she was pregnant, and called at my office a few days later. I did not examine her, but asked her to remain quiet and await developments as I thought possible that she might be pregnant. On the evening of March 1st she fell and sprained herself, and during the same night had a scanty flow. The flow recurred each day, and on the 7th of March she passed the ovum. It was kept in a cool, moist cloth for twenty hours, and when it came into my hands was at once placed in a large quantity of sixty-per-cent. alcohol." †

The ovum is very large for its age, having a long diameter of 10 mm. and a short diameter of 7 mm. It is covered with villi only around its greatest circumference, having two spots without villi, as was the case with Reichert's ovum. The villi of the chorion are from 0.5 to 0.7 mm. long and are branched.

Upon opening the chorion it was found that the germinal vesicle was situated just opposite the edge of the zone of villi. About it was much coagulated albumen, magma reticulare, which I did not remove, and therefore could not obtain good camera drawings. The portion of the chorion to which the vesicle was attached was cut out and stained with alum cochineal and cleared in oil, but even after this treatment it was impossible to obtain any clear picture. The specimen was next embedded in paraffin and cut into sections 10 μ thick. The series proved to be perfect. From the sections a reconstruction was made in wax, and the accompanying Fig. 1420 is a sagittal section of it.

The dimensions of the different portions of the vesicle are as follows:

Diameter of stem	0.4 mm.
Length of stem	0.4 "
Length of vesicle	1.5 "
Width of vesicle	1.0 "
Length of invagination	0.8 "
Width of invagination	0.5 "
Diameter of opening of invagination	0.03 "

The sections and reconstruction show that the embryonic vesicle is attached to the chorion by means of a stem. The greater part of the vesicle itself is composed of two layers, ectoderm and mesoderm. In the neighborhood of the embryonic stem there is a third outer layer which shows all of the characteristics of the ectoderm. Just beside the attachment of the vesicle to the stem there is a sharp, deep and narrow invagination of all three embryonic membranes, which I have interpreted as the formation of the amnion. The arrangement of this invagination is fully pictured in Figs. 1421 to 1425. Within the stem there is a sharply defined allantois which communicates with the cavity of the vesicle just below the cavity of the ectoderm. The ectodermal plate of the invagination is very broad but not of equal thickness throughout its whole extent. It extends to the outside of the vesicle and ends quite abruptly in the neighborhood of the stem. The blood-vesssels of the mesodermal layer extend to the stem but do not enter it, nor are there any blood-vessels in the chorion.

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* An extensive description of the pathology of early human embryos is given by me in the "Contributions to the Medical Sciences," Johns Hopkins Hospital Reports, vol. ix., Baltimore, 1900.

† Letter from Dr. Kittredge, April 27th, 1893.

Since the first publication of this specimen, embryos both normal and pathological have been studied, all of which indicate more and more that this specimen must belong to the pathological class. The other pathological specimens of my collection as well as the perfect normal specimen described recently by Peters all speak for this conclusion. Yet the presence of all three blastodermic membranes in No. XI., with blood islands in the mesoderm, and an allantois in the embryonic stem, indicate that this specimen cannot be far from the normal, but represents the earliest changes in the blastodermic membranes in a specimen of the Peters stage under pathological conditions.

The next stages in the development of the embryonic vesicle are taken from Graf Spee, and they are of importance to elucidate the changes which take place preparatory to the formation of the body cavity. In Fig. 1426, which represents the younger embryo, the amnion is still surrounded completely with mesoderm, as in embryo No. XI., represented in Fig. 1420. The mesoderm crosses the median line, as the sections given by Graf Spee[29] show. The dorsal side of the amnion is covered with a very thick layer of mesoderm, as the closure of the amnion in embryo No. XI. would suggest.

From the stage represented in Fig. 1426 it is easy to pass to the older embryo represented in Fig. 1427. Now the body of the embryo is well marked, the neural folds are just beginning, and the neurenteric canal has just been formed. The chorda dorsalis is not yet separated from the entoderm, and the blood islands encircle completely the umbilical vesicle and have nearly reached the head end of the body of the embryo preparatory to the formation of the heart.

In my earlier studies I was inclined to believe that embryo XI., Fig. 1420, to be normal, but the recent publication of a normal human ovum younger than Reichert's, by Peters, makes this view improbable. Now we must view the opening in the amnion in XI. as a secondary rupture, for in the Peters embryo, which is so much smaller than any yet seen, and the amnion is closed. Furthermore, Selenka has just described a small ovum of the gibbon in which the amnion is still connected with the epithelial covering of the chorion and almost communicates with the exterior of the ovum. These observations practically set to rest this difficult question. The amnion arises directly from the exterior of the ovum, closes at once, and then the embryo forms within it. There is, therefore, apparent inversion of the germ layers.

In these two ova described by von Spee, the cœlom is much of the same form it was in embryo No. XI., Fig. 1420, and therefore needs no special comment. Yet around the head end of embryo Gle. there is a marked accumulation of mesoderm into which the heart is to grow. In the illustrations of the section of this embryo Graf Spee[30] pictures spaces in the mesoderm which he believes to be portions of the body cavity of the embryo, that is, the cavity of the muscle plates, pericardial cavity or peritoneal cavity. It is impossible to determine definitely which portion of the body cavity these spaces represent, but I do not feel inclined to believe that what he marks pericardial cavity in Fig. 1435 can possibly represent it, for we are to look for the pericardial cavity between the junction of the pharynx and umbilical vesicle and the head end of the embryo. This portion of the embryo is marked H in my Fig. 1427, and falls anterior to von Spee's Fig. 16. Von Spee's Fig. 16 is the twenty-fourth section of the embryo, beginning at the head, while his Fig. 23 is the eighty-first section.

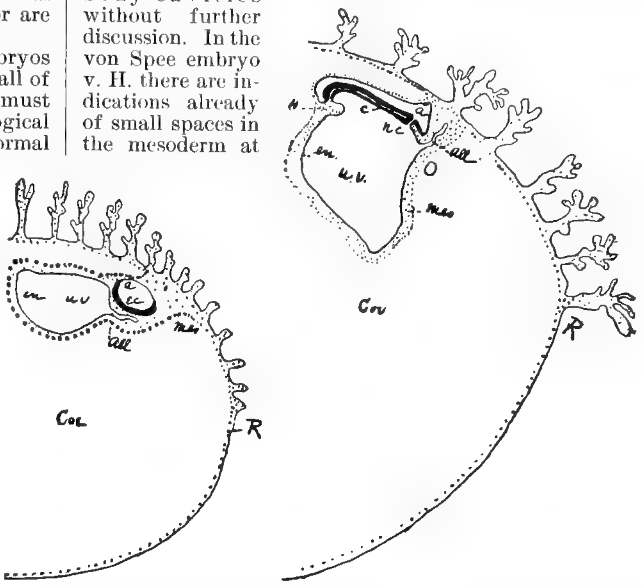

FIG. 1426. FIG. 1427.

FIGS. 1426 and 1427.—Longitudinal Sections of Two Young Human Ova. (After Graf Spee.) Enlarged 10 times. Fig. 1426, Embryo v. H.; Fig. 1427, Embryo Gle. Just half of the chorion is drawn, and the villi are outlined only over a portion of the ovum. *R*, Rauber's layer; *a*, amniotic cavity; *u v*, umbilical vesicle; *en*, entoderm; *mes*, mesoderm; *all*, allantois; *c*, chorda; *n c*, neurentic canal; *H*, position of heart.

The various small spaces in different portions of the mesoderm cannot be viewed as the real origin of the body cavities without further discussion. In the von Spee embryo v. H. there are indications already of small spaces in the mesoderm at the border of the ectoderm of the embryo. Similar spaces are described by Bonnet[31] for the sheep and by Selenka[32] for the monkey. While von Spee and Bonnet believe that these spaces belong to the cœlom, Selenka simply designates them heart, or vascular.

The blood-vessels are intimately associated with the cœlom in their early development, and it is easy to be led into error without an abundance of material. Drasch[33] recently has again emphasized this relation. He has shown in the chick that the blood islands are separated from one another by a number of closed spaces filled only with a fluid. These spaces soon flow together to form the large slit-like cœlom of birds. The same condition of things has been shown to be true, but from a very different method, by Budge.[34] He injected the blastoderm of the chick, and showed that the cœlom was composed of a network of spaces, which gradually flowed together into the large cœlom surrounding the embryo.

Of course in the young human embryos we have at our disposal this stage of the process has long passed, but there is no reason why a remnant of it should not exist at the point of union of the umbilical vesicle with the body. The reason I question von Spee's interpretation of these small spaces in the mesoderm in embryo Gle. is that I believe that all, or certainly nearly all, of the body cavity is formed by an incorporation of the extra-embryonic cœlom within the embryo. What I have observed in human embryos as well as in the injected specimens of Budge shows that this must be true. These small spaces in the mesoderm of the body may belong to the muscle plates and the early blood-vessels, and certainly cannot play any great part in the development of the body cavity. There is no doubt whatever that the whole peritoneal cavity is simply pinched off from the cœlom of the outside of the body, and it is highly probable that the pericardial cavity and pleural cavities are formed in the same way. The anterior mesentery of the intestine has never existed in the human embryo, and it is therefore needless to explain its mode of disappearance.

My statements are based in great part on embryos Nos. III. and XII., and since No. XII. is such a perfect specimen it is well for me to describe it in greater detail. The embryo is about the same age as Kollmann's[35] embryo Bulle, which unfortunately was never fully published. No. III. is an embryo given me by Professor His. This embryo had been torn from the umbilical vesicle, and was injured in different portions of the body. Yet the head end of it is fairly well preserved, and it is of value in determining the growth of the body walls covering the heart.

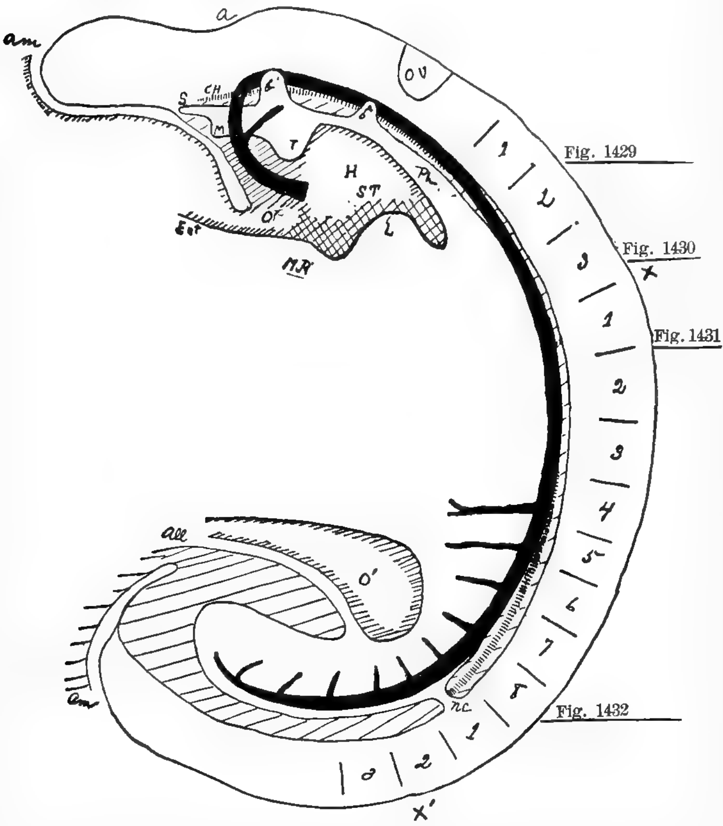

FIG. 1428.—Outline Drawing of a Sagittal Section of the Model of Embryo No. XII. Enlarged 50 times. The heavy line is the aorta. The muscle plates are numbered for occipital, cervical, and dorsal regions, respectively. The mesoderm is striated. *am*, Amnion; *a*, border between forebrain and midbrain; *x* and *x'*, extent of closure of spinal canal; *S*, Seessel's pocket; *ch*, chorda; *b'* and *b''*, first and second branchial pockets; *o v*, otic vesicle; *m*, mouth; *T*, thyroid; *H*, pericardial space; *ph*, pharynx; *ent*, entoderm; *S T*, septum transversum; *l*, liver; *n c*, neurenteric canal; *all*, allantois.

Embryo 2.1 mm. Long.—The history of embryo No. XII. is as follows: "The woman from whom the ovum was obtained is twenty-three years of age and has been married for three years. She is a very intelligent woman, and her statements are reliable. Her menstrual periods recur every thirty days. She had been married some time before she became pregnant, and after passing two periods aborted July 6th, 1893. She was unwell the 5th of October and again on the 7th of November, this last period lasting five days. She passed her next period and on December 18th aborted the ovum."*

The ovum was hardened in strong alcohol without opening it first, and when it came into my hands its dimensions were 18 × 18 × 8 mm., that is, it was slightly flattened. It was completely covered with long villi. It was carefully opened, care having been taken not to injure the embryo in any way. The cœlom was filled with a clear fluid, and many firm shreds of a fibrin-like body which obscured the embryonic vesicle greatly. With much difficulty the embryo could be outlined, and these drawings proved to be of great service in making the reconstruction. The portion of the chorion to which the embryo was attached and the embryo were stained in carmine and embedded in paraffin. The whole was cut into sections, at right angles to the body, 10 μ thick.

Every other section was enlarged 100 times and drawn on wax plates 2 mm. thick, and from them the model of the embryo was made. The model gives the whole central nervous system, the entoderm throughout its extent, the blood-vessels, and the muscle plates.

The shape of the neural tube is given in the diagrammatic outline. It was closed only along the middle of the body, being open in front down to the beginning of the fourth muscle plate. From the beginning of the fourth plate to the beginning of the fourteenth it was closed, and from there on again it was open. In the figure the portions between *x* and *x'* indicate to what extent the tube is closed. In Figs. 1429 and 1430 the tube is nearly closed, while in Fig. 1432 the tail end of the tube is just beginning to separate from the ectoderm. The cephalic end of the tube already clearly outlines the forebrain, the mid-brain, and the hind-brain; the constriction, Fig. 1428, *a*, indicates the junction between the first two. On the ventral side of the fore-brain there are two marked pockets, one on either side, just behind the neuropore, which are no doubt the primary optic vesicles. It shows that in the human embryo these are fully outlined before the brain has separated itself from the ectoderm. Farther behind, very near the dorsal median line and about in the middle of the head, there is a short pocket of thickened ectoderm, the otic vesicle. Toward the hinder end of the embryo the spinal cord communicates by means of a solid band of cells with the entoderm (Fig. 1432). At no point in this communication is there a canal, so it must be viewed as the last remnant of the neurenteric canal. The location is opposite the twelfth muscle plate, or in the neighborhood of what will later on be the position of the first rib. The chorda dorsalis extends to the neurenteric canal, but not beyond it. There is no chorda in the tail end of the embryo.

Throughout the central nervous system, immediately about the central canal, there are many karyokinetic figures, showing that the specimen was excellently preserved. In the greater portion of the neural tube the tissue is already marked by two zones, a central one rich in nuclei, and a peripheral containing none. This corresponds with the description already made familiar to us by His.

The general shape of the whole central nervous system is very unlike that of any other young human embryo ever published. It circumscribes the greater portion of a circle, while in the other human embryos of this size it makes more of a straight line. I think that it is probable that this specimen represents the normal, as it was not injured nor handled in any way before it was cut into sections.

The entoderm, as the figures show, is already divided into fore-gut, mid-gut, and hind-gut. The fore-gut makes the pharynx, from which there are four diverticula on the dorsal side, one on the ventral side, and two near the mouth. The four on the dorsal side mark the first two branchial pockets on either side of the embryo; the two in front are Seessel's pocket and the entodermal portion of the mouth; while the one on the ventral side of the pharynx is the beginning of the median portion of the thyroid gland (Fig. 1429, *t*).

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* Letter from Dr. Ellis, January 7th, 1894.

At the junction of the pharynx with the umbilical vesicle there is a large diverticulum into the septum transversum (Fig. 1430 *l*), the beginning of the liver.

Within the tail end of the embryo, behind the neurenteric canal, the hind-gut is enlarged considerably, and from it the entodermal canal of the allantois arises.

The whole umbilical vesicle is covered with blood-vessels which communicate with the veins and arteries of the embryo. Near the origin of the liver there are two veins which collect the blood from the umbilical vesicle and then enter the heart. These are the omphalomesenteric veins. They with a number of their branches are shown in sections in Fig. 1430, *v*. The heart itself is broken, but there is enough of it left to show that it is bent upon itself and contains a large cavity at the point where the veins entered it. From the heart two arteries arise and pass in front of the first branchial pocket, and each follows the course as shown in black in the reconstruction. The aortæ do not unite, but each sends a number of segmental branches to the umbilical vesicle along the tail end of the embryo. These are, of course, temporary; they may be called collectively the omphalomesenteric arteries. As the permanent omphalomesenteric artery arises more aboral than any of these, it is easy to understand that most of them must degenerate.

The sections show that there are fourteen muscle plates, all of which are hollow and do not in any way communicate with the body cavity in general. Kollmann, who described an embryo of this same age, numbers them from before backward, but I think that they can be designated more definitely. Froriep[36] showed that in all amniotic vertebrates there were a number of muscle plates and dorsal ganglia formed in the occipital region, and studied their fate in the chick and in the cow's embryo. Platt[37] has also followed the order of the origin of the muscle plate in the chick, and found that the first division of the mesoderm was between the third and fourth occipital plates. The first three or four of these segments communicate in the chick, according to Dexter,[38] with the cœlom, and Bonnet[39] has found also that the same is true in the sheep. Bonnet's figures (compare his Plate IV.) show that a sheep's embryo of the same stage as embryo XII. has muscle plates much more sharply outlined than the human. In order to locate the muscle plates more definitely I have made every effort to count the spinal ganglia in embryo XII., but with no definite result. It is impossible for me to define the spinal ganglia, as often they are represented by a few cells only, then again as a band of cells they extend over several segments. The same is true in the occipital region. Had I been able to number them definitely it would still have been impossible to number the muscle plates from them, for His[40] has shown that there is an occipital ganglion in the human embryo as well as in the lower animals.

The fact that the muscle plates reach to the otic vesicle in embryo XII., as well as in Kollmann's embryo Bulle, indicate that the first plates must belong to the occipital region, and I have found that there are three occipital muscle plates in embryo No. II.[41] Moreover, there is every indication of a degeneration of the first two plates in XII., so on this account I am inclined to number them as they are numbered in Fig. 1428. I do not think that any of them ever communicate with the pericardial cavity as Bonnet found them in the sheep. The cavities in all of the other plates are small, and they are separated by a large mass of mesoderm from the cœlom. This all confirms my view.

The chorda extends from Seessel's pocket to the neurenteric canal.

There are also a few segmental ducts, some completely and some partly separated from the ectoderm, as was the case in Kollmann's embryo. The ducts are small, and extend over one or two sections only, and occasionally one of them is arising at several different points between a given two segments. They are present on both sides between the first and second cervical segments, second and third segments, third and fourth segments, fourth and fifth segments, and only on the left side in the region of the fifth and sixth cervical segments.

The cœlom of this embryo is especially instructive. A sagittal section of the embryo and ovum is given in Fig. 1433. This embryo, when drawn connected with the ovum, is very similar to Graf Spee's embryo Gle. as shown in Fig. 1427. It is very easy for us to conceive the von Spee embryo converted into this embryo, for about all the change that is necessary is that the embryo grow somewhat and bend upon itself. In so doing the attachment of the umbilical vesicle becomes smaller as the amnion encircles the body of the embryo more. The position of the neurenteric canal, the shape of the allantois, and the formation of the pericardial cavity, all show that the curving must be a normal one.

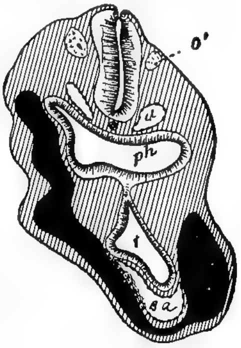

Fig. 1429.

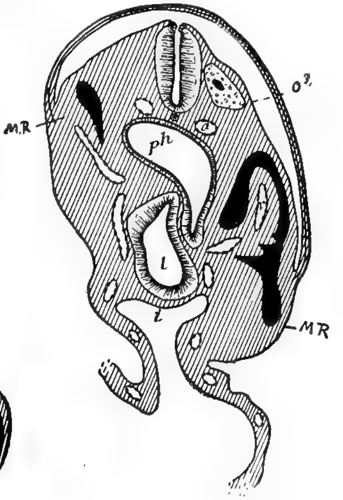

Fig. 1430.

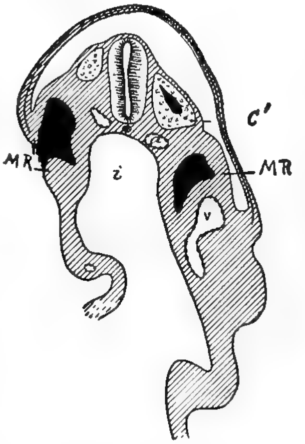

Fig. 1431.

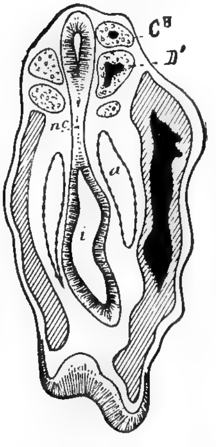

Fig. 1432.

Figs. 1429–1432.—Sections through Embryo No. XII., as indicated by the Lines in Fig. 1428. Enlarged 50 times. The black is the cœlom within the body. O^1 and O^3, First and third occipital muscle plates; C^1 and C^8, first and eighth cervical muscle plates; D^1, first dorsal muscle plate; *a*, aorta; *v*, omphalomesenteric vein; *t*, thyroid; *l*, liver; *ph*, pharynx; *i*, intestine; *n c*, neurenteric canal; *MR*, membrana reuniens.

Nearly all other young embryos of this stage, or a little older, which have been published show a straighter body or even a curve in the opposite direction. I have also in my collection two embryos of this stage, Nos. I. and XV., which had been taken out of the chorion and torn from the umbilical vesicle, and both of them are straight like Kollmann's embryo Bulle and His's[42] embryo L. It is difficult to conceive how my embryo XII. could possibly be torn out of its membranes without straightening it. We need only recall our experience in hardening embryos of lower animals to be reminded how easily a curved embryo is straightened when it is handled the least bit roughly before it is hardened.

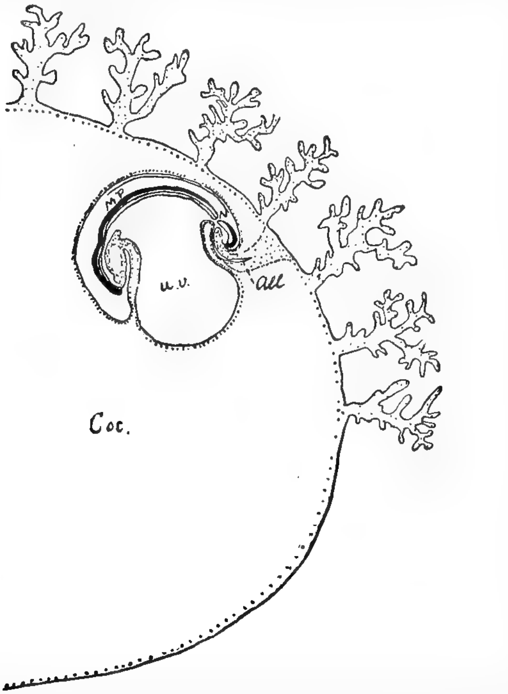

FIG. 1433.—Sagittal Section of the Ovum with Embryo No. XII. Attached. Enlarged 10 times. *Coc*, Cœlom; *u v*, umbilical vesicle; *all*, allantois; *MP*, medullary plate.

His, in his great monograph on human embryos, emphasizes a curve in the back of the embryo just the reverse of the one given in Fig. 1433. I refer to embryos Sch., BB., and Lg., as well as to Minot's embryo 195.[43] The fact that this inverted bend in the back is not constant (His's Rf., for instance), and that it occurs at the time when any tension upon the umbilical vesicle could produce it, makes me believe that it is an artifact. This view was suggested to me a number of years ago, when I was removing young dogs' embryos from the uterus, and unwittingly distorted a number of them in this very way before they were hardened. The middle of the back is the weakest part of the embryo's body, and the umbilical vesicle is attached to it. Under these conditions the simple weight of the vesicle is sufficient to bend the back of the embryo as pictured by His.

To return to the cœlom. At the hinder end of the embryo the cœlom dips into the body overlapping the hindgut in the neighborhood of the neurenteric canal, as shown in Fig 1432. This cavity communicates with its fellow on the opposite side through an opening between the umbilical vesicle and the allantois, marked *O* in Fig. 1428. This communication has already been described by His[44] for an embryo somewhat older. If, now, the point *O* in Fig. 1428 is approximated toward *NC*, with a flexion of the embryo at the same time, this communication is easily explained. In other words, as the hind-gut is being separated from the umbilical vesicle, a groove-like portion of the cœlom is also included in the body of the embryo. At the hinder portion of the embryo, on either side, the cœlomic grooves extend deeper into the body of the embryo, and communicate with each other around the aboral side of the stem of the umbilical vesicle. This communication is shown well by His in Fig. I, B, Plate VI. of his "Atlas," as well as in the same figure, page 299 of Minot's "Embryology." Excellent profile views showing this point are given in all the embryos figured on Plate IX. of His's "Atlas."

I emphasize this point in order to exclude the ventral mesentery for this portion of the embryo. The fact that this mesentery could never have existed in the human embryo is also proved by a careful examination of His's models of human embryos made by Ziegler.

As we pass toward the head in embryo XII. the cœlomic groove communicates freely with the extra-embryonic cœlom until the region of the membrana reuniens is reached. This is shown in Fig. 1431, *MR*, with the membrana reuniens complete on one side, but not yet united on the other. The membrana reuniens extends up to the heart, and separates the pericardial cavity from the extra-embryonic coelom, then crosses the ventral median line to return on the opposite side of the embryo. Throughout the extent of the membrana reuniens there is a great increase of mesodermal tissue, which encircles completely the beginning of the liver, as Fig. 1430 shows. A portion of this mesodermal tissue has been described by His as the septum transversum.[45] According to His only that portion of the mesodermal tissue is septum transversum which lies between the posterior part of the pericardial cavity (*Parietelhöhle*), the wall of the intestine, and the point where the veins enter the heart. It extends across the body, and has within it the beginning of the liver. In transverse section this region is shown in Fig. 1430. Now the pericardial cavity communicates by means of a long canal on either side, with the peritoneal cavity, and the omphalomesenteric vein hangs into this, attached to a kind of mesentery, as Fig. 1430 shows. Lower down, near the communication (Fig. 1431), there is an indication of the beginning of the umbilical vein, which unites with the omphalomesenteric vein through the membrana reuniens. The two canals which communicate with the extra-embryonic cœlom are the pleural cavities, and the membrana reuniens aids to separate them from the peritoneal.

All of the tissues from the diaphragm to the opening of the liver duct into the duodenum arise from the septum transversum and the membrana reuniens; the stomach from the fore-gut, the liver from the liver diverticulum, and the diaphragm from the septum transversum and the membrana reuniens. The Cuvierian duct must also

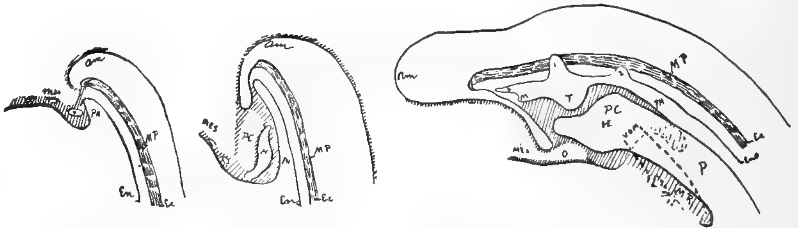

FIG. 1434. FIG. 1435. FIG. 1436.

FIGS. 1434-1436.—Three Stages to Show the Development of the Blastodermic Layers at the Head End of the Embryo. Fig. 1434, Count Spee's Embryo Gle. Fig. 1435, Embryo No. III. Fig. 1436, Embryo No. XII. *V*, Vein; *ph*, pharynx; *am*, amnion; *MP*, medullary plate; *p c*, pericardial cavity; *S*, Seessel's pocket; *m*, mouth; *t*, thyroid; *1* and *2*, first and second branchial pockets; *p*, pleural cavity; *m r*, membrana reuniens; *vom*, omphalomesenteric vein, which is expressed as a dotted line; *O*, communication between right and left body cavities on the ventral side of the umbilical vesicle.

have arisen in the membrana reuniens, in order to pass around the outside of the body cavity to reach the cardinal and jugular veins, as pictured by His[46] for the human embryo.

In the further development of the pleural and pericardial cavities the Cuvierian veins give us our best landmark, as they define the point where the pleural cavity is to be separated from the pericardial. And it really seems as if the greater portion of the diaphragm is formed from the portion of the septum transversum on the ventral side of the vein and from the membrana reuniens, rather than from the portion immediately in front of the intestine. In other words, there is a horseshoe-shaped ridge of tissue around the neck of the embryo to the ventral side of the pericardial and pleural cavities and parallel to them. The median portion is composed of the septum transversum, and each wing of the *shoe* is the membrana reuniens, one on either side of the embryo. Its general direction in this stage is parallel with the long axis of the embryo, and within each wing there is an omphalomesenteric vein.

Origin of Pericardial Cavity.—With the pericardial cavity opening into the extra-embryonic cœlom on either side as a basis, it is possible to trace back the pericardial cavity to its origin. Figs. 1428 and 1436 show that the ventral wall of the pericardial cavity is composed mostly of mesoderm. This is the portion of the membrana reuniens which is composed of mesoderm, as the sections, Figs. 1430 and 1431, show. An earlier stage is shown in the diagrammatic Fig. 1435. It is taken from embryo No. III. In this specimen, since the ectoderm of the amnion has not reached completely around the body, as both the sagittal and transverse sections show (Figs. 1435 and 1437), it is evident that the pericardial space is first covered on the ventral side with mesoderm and later the ectoderm is added when the amnion begins to close over the head. In embryo III. the canals communicating between the pericardial space and the extra-embryonic cœlom are not as long as in embryo XII., and the ventral walls of the pericardial space are composed wholly of mesoderm. This indicates that the growth of this wall was first by a union of the mesoderm, which was followed by the ectoderm of the amnion to complete the body wall. The process is shown in Figs. 1434 to 1436. Fig. 1434 is a hypothetical stage between Graf Spee's embryo Gle. and my embryo No. III. As the process from Graf Spee's embryo continues, the blood-vessels reach the body to form the heart, as indicated by the outlines marked *v* in Fig. 1434. The mesoderm of the amnion then unites with that of the umbilical vesicle, and the first pericardial space is formed. This is not wholly an imaginary stage, for it is based upon Bonnet's observations upon the sheep,[47] as well as Cadiat's upon the chick.[48] In a sagittal section of a sheep's embryo of about the same stage (Plate III., Figs. 16–20, c CB) Bonnet gives a similar fold, and after the pericardial walls are well formed he gives an illustration of a stage in which it still communicates with the extra-embryonic cœlom (Plate IV., Fig. 17, KC). With Graf Spee's embryo Gle. and with Bonnet's observations upon the sheep as a starting-point, it is not difficult to interpret Figs. 1434–1436.

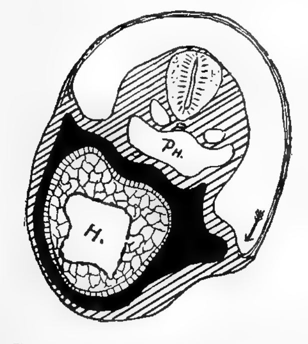

FIG. 1437.—Section through the Head of Embryo No. III. Enlarged 55 times. *Ph*, Pharynx; *H*, heart. The arrow in the amniotic cavity indicates the direction of the future growth of the amnion to complete the ventral body wall.

Extension of the Amnion.—After the stage of embryo XII. is passed the amnion rapidly envelops the whole body and soon passes out over the cord. The next stage after No. XII. which I have studied is No. XIX. I have very perfect photographs of this specimen, and the sections are all good, although the nervous system is macerated. The embryo has rotated in the amnion, throwing the cord to the right side with the left side toward the observer. It would have been impossible to obtain a view of the right side of the embryo without cutting the cord. The outlines of this embryo and ovum are given in Fig. 1438. Two sections through the body are given in Figs. 1439 and 1440.

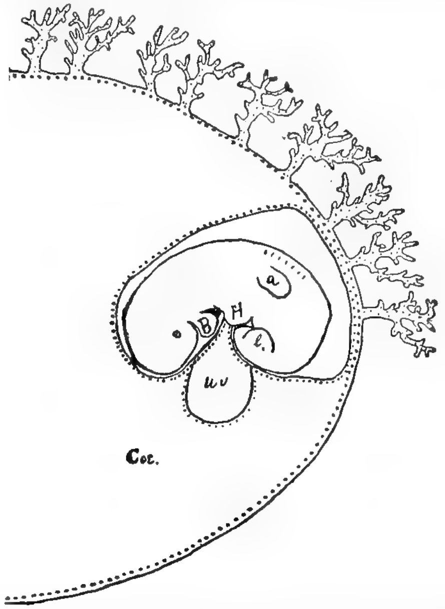

FIG. 1438.—Ovum and Embryo No. XIX. Enlarged 5 times. Just half of the ovum is shown. *a*, Arm; *l*, leg; *H*, heart; *u v*, umbilical vesicle; *B*, branchial arch.

The amnion has become separated from the body with the exception of the part about the cord and also that along the right side of the body, over the heart. The arrow in Fig. 1437 shows how the amnion on that side is extended over the ventral body wall to make the condition shown in Fig. 1440. No doubt the cause of this is the rotation of the body, throwing the cord to its right side and the amnion with it. In nearly all young embryos the cord is on the right side.[49] With the exception of the four instances mentioned below, the rotation has always been so as to throw the left side of the body away from the chorion, and in all of these specimens the amnion must have swept over the body from left to right, as shown in the figures. I find a similar illustration by His in his great monograph.[50]

Absence of a Ventral Mesentery.—After the septum transversum has been formed as it is in embryo XII., there is on its ventral side a pretty sharp groove, which indicates that the umbilical vesicle is being constricted at this point.

It is generally believed that the ventral mesentery of the intestine extends to the umbilicus, and that ultimately the round ligament of the liver represents its remnant after most of it has disappeared. This theory is expressed by two diagrams in Minot's "Embryology," page 767. As the liver begins to grow, and while the heart is being pushed down in front of it, the ventral end of the septum transversum is turned down to the umbilicus. While this is taking place the stem of the umbilical vesicle becomes relatively smaller and smaller, but there is no union between the umbilical vesicle and the septum transversum as expressed in Minot's diagram. The first stage of this process is shown in my Fig. 1436, and its successive stages are shown in His's "Atlas," Plate IX. In all six embryos pictured on that plate the successive stages are represented, and in none of them is the umbilical vesicle attached to the septum transversum to form a ventral mesentery. From these embryos of His we can pass to embryo XIX., in which the umbilical vesicle communicates by a round canal with the intestine, and the tube is completely encircled with a space which extends to the liver, thus cutting off any possible ventral mesentery at that point. The same thing is shown, but in a later stage, in Fig. 1442, *O*, but a new process has already taken place to complicate matters.

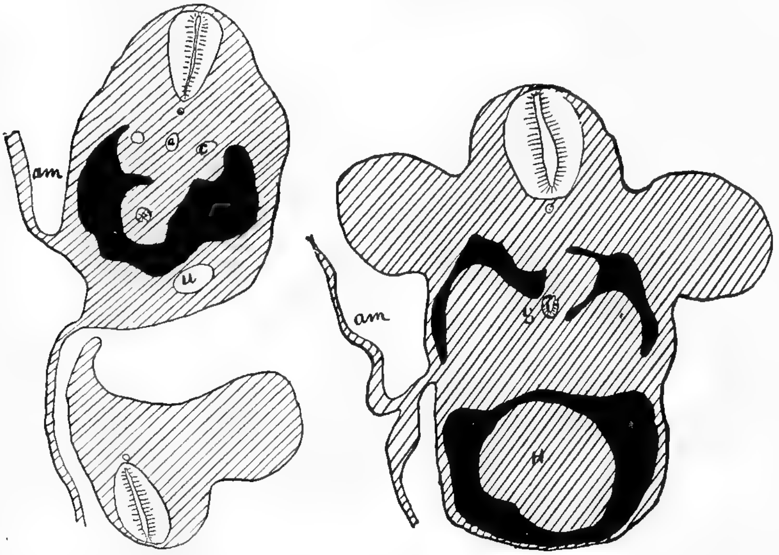

FIG. 1439.

FIG. 1440.

FIGS. 1439 and 1440.—Section through Embryo XIX. to Show the Attachment of the Amnion to the Side of the Body. Enlarged 25 times. *Am*, Amnion; *S*, stomach; *H*, heart; *c*, cardinal vein; *u*, umbilical vein; *a*, aorta.

In embryo XII. there is just a beginning of an umbilical vein in the membrana reuniens. In Kollmann's embryo the vein is more marked.[51] The vein extends out into the somatopleure, far away from either the intestine or the median line. This same position is again shown in His's embryos BB. and Lr. on Plate IX. in his "Atlas." The left umbilical vein becomes the more prominent, and as the body wall is developed more and more it moves around toward the ventral median line. This movement takes place in common with the movement of the amnion over the body from left to right, as shown in Fig. 1440. In embryo No. II., however, the liver has nearly reached the umbilicus, and the vein has almost moved around to the ventral median line, as shown both in the reconstruction and the sections (Figs. 1442, 1437–1451). After the vein has moved around the body to its ventral surface, and after the liver moves away from the umbilicus up to the permanent diaphragm, it is easy to explain the formation of the round and broad ligaments of the liver as a secondary formation, but not as a remnant of a ventral mesentery. It might be called a portion of the septum transversum, as it is directly continuous with it. A ventral mesentery does exist between the abdominal walls and the liver, and extends only slightly below the liver. It is always slightly to the left of the median line, and is in direct connection with the septum transversum (Fig. 1442, *O* and *ST*).

Cœlom of Embryo No. II.—After the body cavity is beginning to separate from the extra-embryonic cœlom, the next important stage is the one after the separation is complete, as from now on the adult body cavities are formed by a simple division and expansion of the cavities already within the body. This stage is represented in embryos XVIII., II., and IV. All of these embryos are nearly of the same size, the successive stages being in the order they are given. No. XVIII. is somewhat distorted in the middle of the body, while No. IV. is slightly macerated. No. II. is a perfect specimen, and has been already described by me several years ago.[52] I shall confine my description of it to the body cavity.

The external form of the embryo within the ovum is given in Fig. 1441. The position of the umbilical vesicle, as well as the extent of the amnion and the relation of the umbilical vesicle and amnion to the chorion, are all given. The umbilical cord is large and lies on the left side of the body, while in most embryos already published it is upon the right side. The cord is short, and midway between the embryo and its attachment to the chorion it shows a decided enlargement. The umbilical vesicle is large, measuring 5 × 7 mm., and is located between the head end of the embryo and the chorion.

The amnion has not grown very much, still leaving a great space between it and the chorion, the extra-embryonic cœlom (compare with Fig. 1438). Within it hangs this large umbilical vesicle, the lumen of which no longer connects with the alimentary canal. The separation is now complete. Around the stem of the vesicle the extra-embryonic cœlom communicates freely with the body cavity, as shown in Fig. 1442. This figure is from a reconstruction, and shows the general extent of the body cavity within the embryo. It encircles the heart, and then extends to the lungs and over them and to the stomach, over the intestines, and out into the cord. A cast of the whole cavity is also given, showing the slit on the dorsal side for the mesentery of the intestine, and the grooves on either side of this for the Wolffian bodies. There are also grooves in the cast

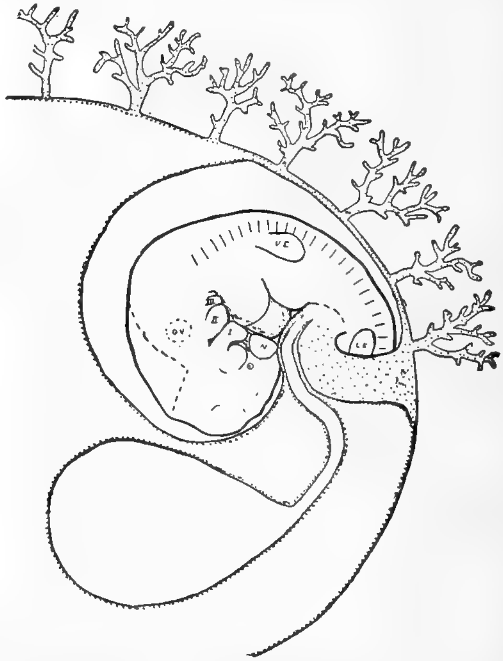

FIG. 1441.—Embryo No. II. Attached to the Chorion. Enlarged 5 times. Just half of the ovum is shown. *o v*, Optic vesicle; *U E*, upper extremity; *L E*, lower extremity; *N*, nose; *I*, *II*, *III*, branchial arches.

for the veins, and the place where the Cuvierian duct enters the heart is marked *V.* The sagittal section of the peritoneal cavity is given in Fig. 1444. The striated line indicates where the cavity crosses the median line of the body, while the other lines outline the cavity beyond. *Lp.* outlines the lesser peritoneal cavity. Figs. 1445–1451 give the extent of the peritoneal cavity in different portions of the embryo, as indicated by the lines in Fig. 1442.

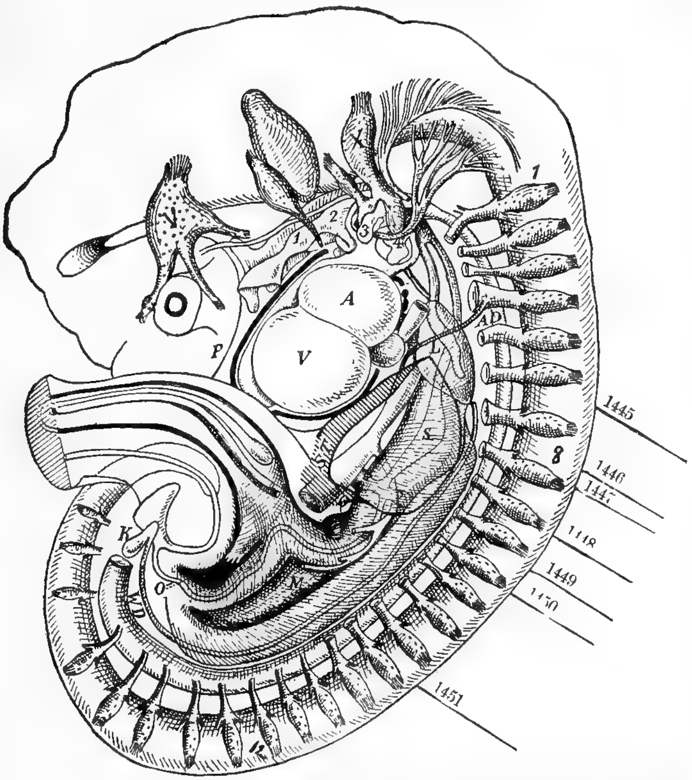

FIG. 1442.—Reconstruction of Embryo No. II. Enlarged 17 times. *V* and *X*, Fifth and tenth cranial nerves; *1, 2, 3,* and *4*, cast of the branchial pockets; *1* and *8*, first and eighth cervical nerves, from the fourth the phrenic arises; *12*, twelfth dorsal nerve; *A*, auricle; *V*, ventricle; *L*, lung; *S*, stomach; *P*, pancreas; *W D*, Wolffian body; *K*, kidney; *M*, mesentery; *S T*, septum transversum; *O*, openings which communicate with the peritoneal cavity of the opposite side. The black line around the heart marks the pericardial cavity.

It is not difficult now to imagine the body cavity of embryo XII. converted into the one just described. In that embryo the heart is high in the neck on the oval and dorsal side of the septum transversum. In this embryo it is on the ventral and oral side of the septum transversum, but still above the eighth cervical nerve. The septum transversum has already received its nerve supply from the fourth cervical nerve, as pointed out in the early part of the century by von Baer. This movement of the septum transversum is accompanied by a movement of all the other organs on their way into the thorax and abdomen of the future individual. In the rotation the Cuvierian duct acts much as the fixed point about which the cœlom is bent. The figures all illustrate this beautifully. But as the heart has rolled over the liver, and the septum transversum has undergone a quarter-revolution, the Cuvierian ducts and all have moved away from the head. This is by no means the end of the excursion of the septum transversum, as its dorsal end must move down and beyond the twelfth dorsal segment (compare Fig. 1442).

The pericardial cavity surrounds the whole heart, as the various figures show. The cavity is traversed only where the large veins enter, and where the aorta leaves the heart. The cavity completely surrounds the bulbus aortæ to its origin (Figs. 1444–1447) in the ventricle. On the dorsal side of the heart the pericardial cavity is separated by a bridge for the transmission of the veins to the heart. Between the bulbus aortæ and the entrance of the veins into the heart the pericardial cavity crosses the median line as three distinct openings, as expressed by the black areas in front of the trachea in Fig. 1442. On the dorsal side of the heart on either side of the lungs the pericardial cavity communicates with the pleural cavities by means of two openings (Fig. 1445), each of which is about 0.1 × 0.5 mm. in diameter. Farther on, the pleural cavities extend as two slits which encircle the lobes of the liver and separate them from the alimentary canal on the one hand and from the body wall on the other (Figs. 1446–1449). The two pleural cavities do not communicate with each other around the lungs, leaving for them both a dorsal and a ventral mesentery.

This appearance of the cœlom about the lungs and the liver can be explained by the lungs and liver both growing into the two pleural cavities of embryo XII., and this has often made me think that the membrana reuniens of embryo XII. is the main origin of what is called septum transversum in embryo II. If this proves to be the case, then the lower end of the membrana reuniens will form the ventral end of the diaphragm, and not the reverse. A stage between embryos XII. and XVIII. (Fig. 1453) is required to elucidate this point.

In the neighborhood of the stomach the peritoneal cavity on either side of it has become asymmetrical, as Fig. 1448 shows. The mesentery has become bent to the left side, leaving a diverticulum from the right side which extends oralward to the tip of the lung (Figs. 1446 and 1447) to form the beginning of the lesser peritoneal cavity.[53] Further aboralward the cavities become symmetrical again (Figs. 1449, 1450), and then unite along the ventral median line, as shown in Fig. 1451. The ventral mesentery shown in Fig.

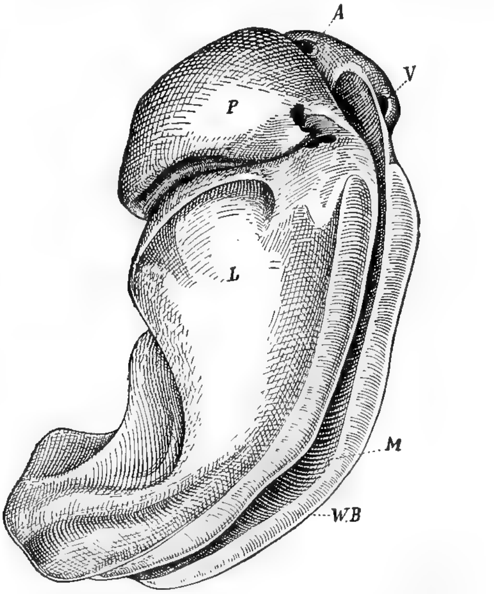

FIG. 1443.—Cast of the Body Cavity of Embryo No. II. Enlarged 22 times. *A*, Position of the aorta; *V*, position of the vein; *M*, position of the mesentery; *W B*, position of the Wolffian body; *P*, pericardial cavity; *L*, cœlom over liver.

1450 does not extend more than a section or two beyond the liver, and is separated by a marked opening from the stem of the umbilical vesicle in this embryo, as is shown in Fig. 1442, *O* (see also No. XII., Fig. 1428, *O*). On the aboral side of the umbilical cord the peritoneal cavities of the two sides unite in both embryos again, marked *O′* in both figures.

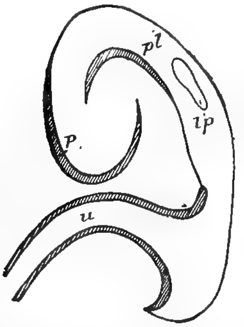

FIG. 1444.—Outline of Cœlom in Embryo No. II. in Sagittal Section. The striated line indicates that the cœlom crosses the median line. *P*, Pericardial space; *pl*, pleural cavity; *l p*, outline of lesser peritoneal cavity.

Development of the Diaphragm.—It has often been stated that the development of the diaphragm, especially in the human embryo, belongs to one of the most difficult problems of embryology, partly because of the difficulty of obtaining the necessary specimens and partly because there are no fixed points from which to calculate. In its development the whole diaphragm wanders from the head to the abdomen, forming as well as modifying the structures and organs along the way. So while von Baer[58] recognized that the diaphragm wandered in its development, picking up its nerve in so doing, a fairly clear picture of the whole process was not given until Cadiat,[59] His,[60] Uskow,[61] and Ravn[62] studied carefully the development of neck, heart, lungs, and intestine. In so doing His especially recognized the anlage of the diaphragm in a mass of tissue located with the heart amongst structures belonging to the head and containing within it the veins to the heart as well as the anlage of the liver. This mass of tissue His termed the septum transversum. His's studies were made upon the human embryo, mainly by the method of reconstruction, and shortly after they were published Uskow made a very careful study of the further growth of the septum transversum. Uskow recognized the great importance of two additional structures in the formation of the pericardium and adult diaphragm from the septum transversum: these he termed the *pleuro-pericardial membrane*, containing the phrenic nerve and the *pillars* which form the dorsal end of the diaphragm. The pillars of Uskow have been termed the *pleuro-peritoneal membranes* by Bracket, and as this term is more appropriate it should be adopted.

My own studies show that the pleuro-pericardial and pleuro-peritoneal membranes arise from a common structure which grows from the lobe of the liver along the dorsal wall of the ductus Cuvieri to the dorsal attachment of the mesocardium. Later it extends toward the head to complete the pleuro-pericardial membrane, and then toward the tail to complete the pleuro-peritoneal membrane. This structure, which I term the *pulmonary ridge*, giving rise to the pleuro-pericardial and pleuro-peritoneal membrane, is located in the sagittal plane of the body cavity with cephalic and caudal horns on its dorsal side. The ductus Cuvieri lies between these horns.

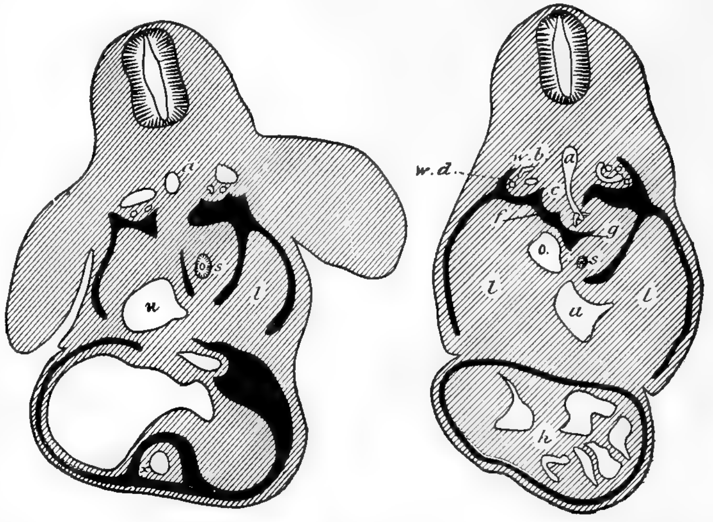

FIG. 1447.

FIG. 1448.

FIGS. 1447 and 1448.—Sections through Embryo No. II. *a*, Aorta; *s*, stomach; *l*, liver; *u*, umbilical vein; *x*, bulbus aortæ; *h*, heart; *o*, omphalomesenteric vein; *g*, lesser peritoneal cavity; *f*, foramen of Winslow; *c*, cœliac axis; *w.b.*, Wolffian body; *w.d.*, Wolffian duct.

In following the fate of the septum transversum it is necessary to consider the division of the body cavity into the pericardial, pleural, and peritoneal cavities. According to His, the body cavity is divided into the *Parietalhöhle* and *Rumpfhöhlen*. The communication between these spaces he has also termed the recessus parietalis. The parietal cavity from its earliest appearance contains the heart and is destined to form the pericardial cavity. This is the pericardial cœlom. A portion of the recessus parietalis forms the pleural cavity; it surrounds the lung buds throughout its development and forms the pleural cœlom. The remainder of the recessus parietalis to the origin of the liver has developed in it the liver and stomach; this is added to the general peritoneal cavity and may be termed the peritoneal cœlom. In the early embryos the whole cœlom lies far out of its final place; in embryo XII. nearly the entire cœlom lies in the region of the head and neck, and in the further development of these parts the cœlom with the surrounding organs wanders away from the head to its permanent location. As long as the serous cavities arising from the cœlom are in the process of wandering and are not fully separated from one another, they may be termed pleural, pericardial, and peritoneal cœlom; when they are fully established they form these cavities.

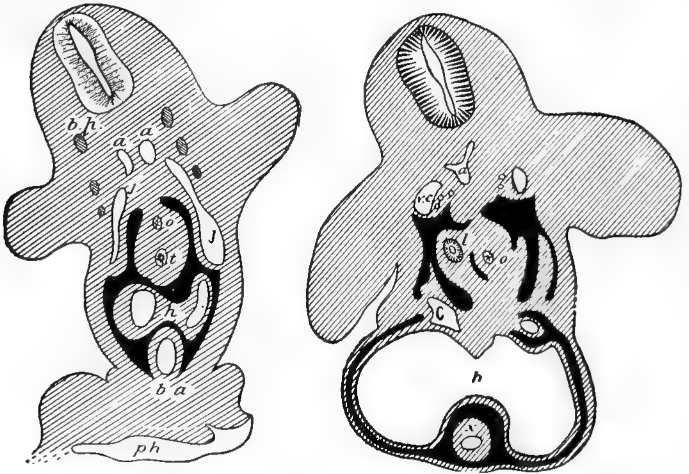

FIG. 1445.

FIG. 1446.

FIGS. 1445 and 1446.—Sections through Embryo No. II. at the Points Indicated in Fig. 1442. Enlarged 22 times. *B p*, Brachial plexus; *a*, aorta; *b a*, bulbus aortæ; *ph*, pharynx; *h*, heart; *t*, trachea; *o*, œsophagus; *j*, jugular vein; *l*, lung; *v c*, cardinal vein; *C*, Cuvierian duct.

In embryo XII., Fig. 1433, the cœlom of the embryo forms a free space encircling the heart and extending on either side of the body over the omphalomesenteric veins to the root of the umbilical vesicle. This canal of communication has developed within it the lung, stomach, and liver, and throughout its earlier development it always measures in length about one-fourth of that of the body. The appearance of the lung and liver marks the subdivision of the cœlom into the pleural and peritoneal cœlom. With the development of the liver, lung, and stomach the cœlom containing them gradually dilates until the embryo is about 9 mm. long, when the containing canal evaginates, so to speak, and turns the liver and stomach out into the general peritoneal cavity. The Wolffian body, which occupies the dorsal wall of the canal, gradually degenerates, and the lung takes its place. From these statements it is readily inferred that the canal extending from the pericardial cœlom, His's recessus parietalis, gives rise to the pleural cœlom on its dorsal side and to the peritoneal cœlom on its ventral side. The line of division is formed by the pleuro-peritoneal membrane extending from the ductus Cuvieri to the adrenal.

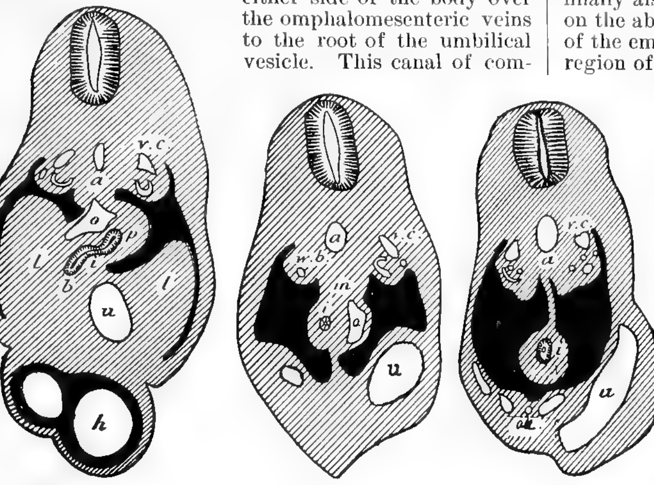

Fig. 1449. Fig. 1450. Fig. 1451.

Figs. 1449–1451.—Sections through Embryo No. II. *a*, Aorta; *v.c.*, cardinal vein; *o*, omphalomesenteric vein; *p*, pancreas; *i*, intestine; *b*, bile duct; *l*, liver; *h*, heart; *u*, umbilical vein; *m*, mesentery; *w.b.*, Wolffian body; *all*, allantois.

It is now no great task for me to give the development of the diaphragm in the human embryo, for I have at my disposal excellent sections, as well as definite knowledge of the anatomy of the surrounding organs contributed by the above-mentioned authors.

While the embryo is still straight it is very easy to locate the various organs and their relations to one another, but through their shifting and the flexion and extension of the embryo the relations are constantly changing, and one must not rely too much upon sections or else erroneous impressions will often be obtained. At first the heart is upon the oral and dorsal side of the septum transversum, then on its ventral side, and finally again on its dorsal side. At first the lungs are on the dorsal side of the heart, then on the lateral side, and finally also on the ventral side of it. At first the liver is on the aboral side of the septum transversum in the head of the embryo, then on the dorsal side of it in the cervical region of the embryo, then as the liver is descending in its excursion it is transferred to the ventral side of the septum and extends into the sacral region. At first the Wolffian body extends high into the thoracic region of the embryo, but while it is degenerating and the diaphragm descends, the upper part of the posterior cardinal vein remains, while the lower part is incorporated with its vena cava inferior, as shown by Hochstetter.[63] As the Cuvierian ducts and cardinal vein descend into the thorax, the segmental veins entering the cardinal veins are gradually shifted, so that veins which originally emptied into the posterior cardinal now empty into the anterior cardinal. While the whole process is taking place the arteries arising from the descending aorta also shift, as I have shown in a previous communication.[64] At that time my collection of human embryos was very limited, and it was necessary to include some observations on lower animals to prove my point, but now I can give a complete table of human embryos in which the point of origin of the cœliac axis is recorded.

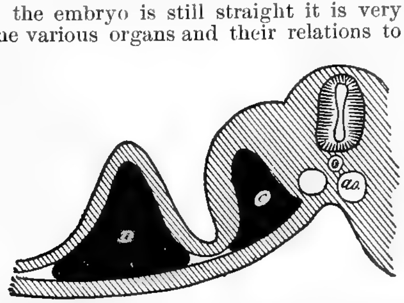

Fig. 1452.—Section of a Chick to Show that the Body Cavity Communicates with the Extra-Embryonic Cœlom. Although the embryo has been injected, the injection masses *a* and *c* are not continuous.

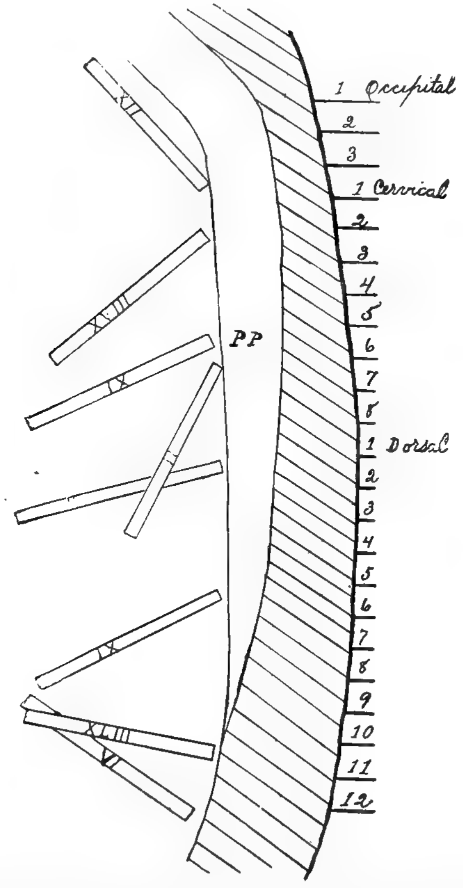

Fig. 1453.—Diagram to Show the Position of the Diaphragm. The numbers on the blocks indicate the embryos from which the diaphragms are taken. *KO* is His's embryo K O: *PP*, the outline of the opening between the pleural and peritoneal cavity, which is finally closed when the diaphragm reaches the tenth dorsal segment.

TABLE SHOWING POINT OF ORIGIN OF CŒLIAC AXIS.

Embryo.	Length in millimetres.	Origin of cœliac axis.
No. XII	2.1	Opposite 4th cervical nerve.*
His's Embryo M	2.6	" 1st dorsal " †
" " B	7	" 2d " " ‡
No. II	7	" 4th " "
His's Embryo A	7.5	" 6th " " §
No. XLIII	13	" 10th " "
" IX	14	" 11th " "
" XXII	18	" 11th " "
" XVII	16	" 12th " "
" LVII	20	Below 12th " "
Adult	....	" 12th " "

* In the first two embryos the omphalomesenteric artery is noted, and not the cœliac axis.
† Compare Fig. 15, Pl. vi., His's "Atlas," with M4, Pl. vii.
‡ Compare Fig. 35, Pl. ii., His's "Atlas," with Fig. 1, Pl. i.
§ Compare Figs. 79 and 86, His's "Atlas," with Fig. 4, Pl. i.

The table shows that the arteries arising from the ventral side of the aorta to supply the stomach and intestines are constantly shifting until their definite origin is finally reached. In these specimens the omphalomesenteric artery is shifted ahead of the cœliac axis. In embryo No. II. the omphalomesenteric artery has a double origin from the aorta, which indicates that this movement may be brought about by a new anastomosis forming, which is then followed by an occlusion of the old origin. At any rate it is impossible that the whole aorta shifts with the abdominal viscera, for it is bound to the vertebræ and muscle plates through the segmental arteries.

The various sections and the reconstruction of embryo No. II. show the pleural and pericardial cavities still communicating freely. The same is true in embryos XIX., XVIII., and IV. Immediately after this stage there are no embryos in my collection, so I have no specimen in which the communications between the pleural and pericardial cavities are just closing. In embryos VIII., V., IX., and XLIII. (Figs. 1453–1455), the pleural and pericardial cavities are separated, while the pleural and peritoneal still communicate. In the embryos with a vertex breech measurement exceeding 17 mm. the pleural and peritoneal have been separated completely.

The separation of the pleural from the pericardial cavity is dependent upon the complete development of the diaphragm. At first the septum transversum and the membrana reuniens are on the ventral side of the pleural cavity, and both are still located within the head. As the septum transversum descends into the body it is next located on the dorsal side of the heart. In other words, the dorsal end of the septum transversum has not moved as rapidly as the ventral end, and thus the whole mass of tissue has turned a quarter revolution. This is accompanied by the extreme flexion of the head, as represented in embryo No. II. At this time the septum transversum has descended to the lower part of the cervical region. Now the septum begins to turn in the other direction again, for with the development of the neck the ventral end of the septum becomes the fixed point and the dorsal end moves more rapidly. The successive stages in the movement of the septum are best shown in the diagrammatic Fig. 1453.

Fig. 1454 shows the septum transversum on the ventral side of the stomach and the pleural cavity communicating with the peritoneal at the point *X*. The Wolffian body and the suprarenal capsule, which is very large, have receded markedly, and the pleural cavity already forms a pocket on the dorsal side of them. A sagittal section through this region, somewhat distant from the median line, is given in Fig. 1457. A transverse section of the embryo pictured in Fig. 1454 is given in Fig. 1455. This section is just at the point above the opening, and shows the communication between its pleural and peritoneal cavities closed on one side, but open on the other. There is a ridge on the side of the cavity which projects between the lung and the liver and continues down to the suprarenal capsule. This ridge has been well described by Ravn,[65] who gives an excellent illustration of the opening with the ridge encircling it.

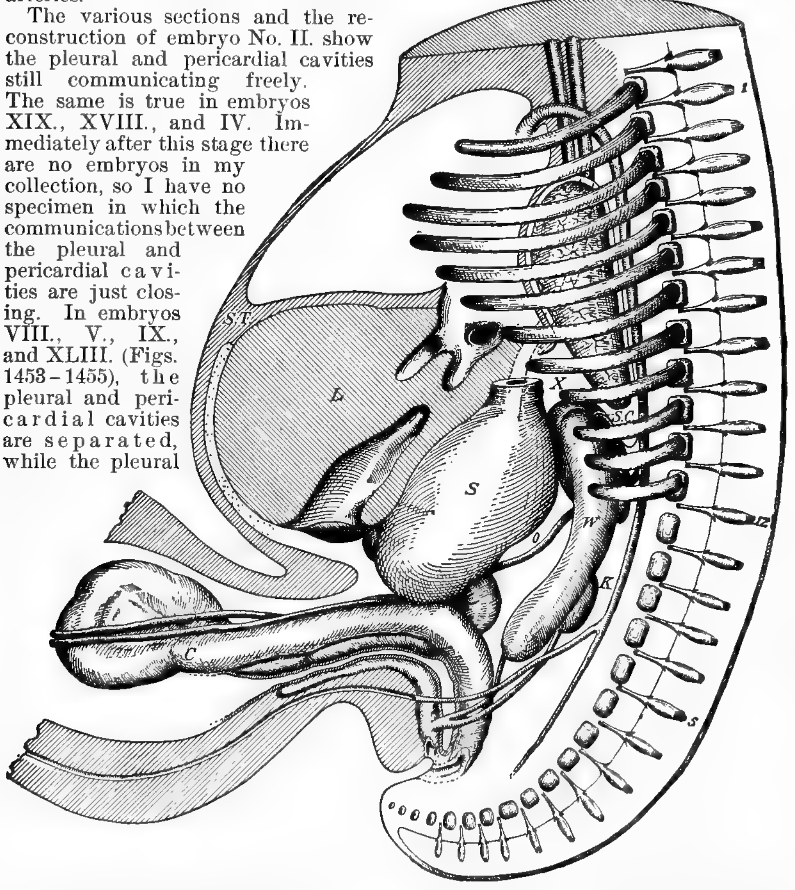

FIG. 1454.—Reconstruction of Embryo No. IX. Enlarged 17 times. *S.T.*, Septum transversum; *L*, liver; *S*, stomach; *C*, cæcum; *W*, Wolffian body; *K*, kidney; *1–12*, dorsal ganglia; *o*, omphalomesenteric artery. The ventral mesentery of the liver is dotted, as it is only a thin membrane; *S.C.*, suprarenal capsule; *X*, point of communication between pleural and peritoneal cavities.

In all the embryos in which the pleural and peritoneal cavities still communicate, the vena cava does not yet communicate with the posterior cardinal vein.

Fig. 1457 is from an embryo slightly larger than the one from which Fig. 1454 was taken. The pleuro-peritoneal communication has just closed by the walls of the ridge having grown together; the extent and shape of the pleural cavity is much as it is in Fig. 1454. The Wolffian body is smaller, and the kidney and suprarenal capsule have come together.

The story, then, is brief: as the diaphragm descends, its dorsal end is in apposition with the suprarenal capsule, and finally, when the capsule approaches the twelfth rib, a ridge of tissue which also includes the capsule unites with a ridge from the septum transversum, and the opening is closed. These two ridges, however, are portions of one and the same ridge, as they form a circle and in section appear as two ridges. The circle is closed much after the fashion of tying up a bag.

All of the abdominal organs, with the exception of the kidney, descend; and the descent is not completed until the pelvis is formed to admit some of them. In the stages pictured nearly all the small intestine lies in the umbilical cord, as is the case in many mammalian embryos. In embryo X. (Fig. 1457) a large portion of the liver also projects into the cord. I have also observed a hernia of the liver in another embryo somewhat larger. I do not consider the form of embryo X. altogether normal, but this was not noticed until the reconstruction was complete.

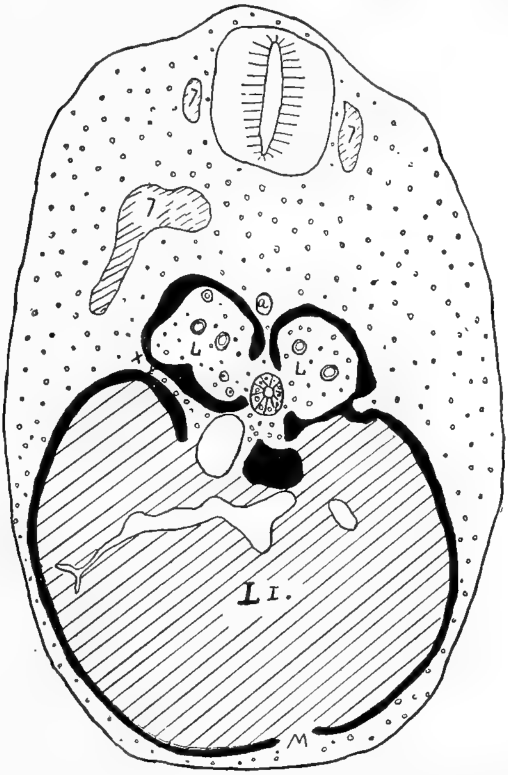

FIG. 1455.—Section through the Point of Communication between the Pleural and Peritoneal Cavities in Embryo No. IX. Enlarged 15 times. 7, Seventh rib; *L*, lung; *Li*, liver; *M*, ventral mesentery of liver; *a*, aorta. The diaphragm is complete on one side, *X*, while it is incomplete on the other.

Closely associated with the closing of the pleuro-peritoneal opening is the development of the cœliac ganglion. In these young embryos it is extremely large, and can be outlined already, while the septum transversum is still high in the thorax. As the septum descends, the various communicating branches of the nerves are caught up with the cœliac ganglion and dragged along. This accounts for the high origin of the splanchnic nerve.

Fig. 1458 (embryo VI.) shows that all the tissues are becoming more definitely outlined, and the whole structure is firmer than in embryo X. The organs of the abdomen are more firmly clustered together, and the intestine has become more convoluted. The lung is much larger, and the pleural cavity extends to the ventral wall of the embryo, obscuring wholly the outline of the heart. In general it confirms everything given in Fig. 1457.

Minot[66] has stated that the pleural cavities are to be considered a portion of the septum transversum, because they lie on the dorsal side of it. From what has already been said above it will be seen that I consider the septum transversum the mass of tissue between the pericardial cavity, the pleural cavities, and the opening between the two sides of the peritoneal cavity immediately below the liver, marked *O* in Figs. 1428 and 1442. This tissue includes the membrana reuniens, which is really the wings of the septum transversum as described by His. In my account I have employed the term membrana reuniens wherever possible to avoid confusion, and have usually employed the terms septum and primitive diaphragm as synonyms.

There are developed within the region of the septum transversum the whole liver, including its ventral mesentery, the lesser peritoneal cavity, the stomach, and the suprarenal capsule. This same region which I have marked out by these three boundaries as the septum transversum is still sharply defined in the adult. The point *O* in Figs. 1428 and 1442 is still as definably marked as ever by the round ligament, foramen of Winslow, and the duct passing from the liver to the duodenum. The round ligament is developed by the umbilical vein shifting around the side of the abdominal walls into the ventral mesentery of the liver, and then when the liver is retracted from the umbilical cord, the vein and mesentery remain as the round and broad ligaments respectively.

Lesser Peritoneal Cavity.—I have already discussed the lesser peritoneal cavity in a separate paper,[67] and find that I can confirm all that I have stated at that time. I can only add that the portion of it extending up under the lung degenerates, while the omental sac is growing rapidly. I have also found that it is extremely easy for the omentum to find its way over the large intestine. At the time this takes place the large intestine is in the median line, while the stomach and the omentum are on the left side of the body. After the intestine is retracted from the cord the cæcum falls over to the right side of the body, while the descending colon is shifted to the left side, and the omentum then comes to lie on the ventral side of the transverse colon.

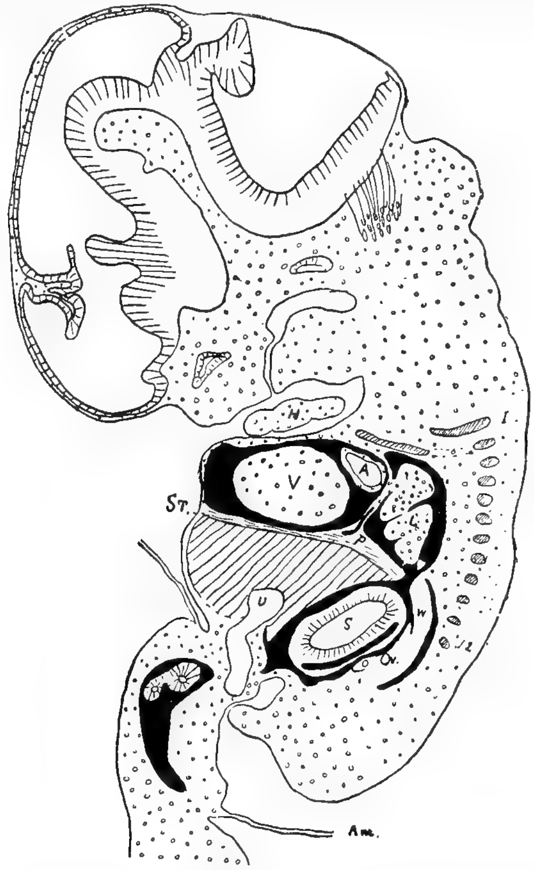

FIG. 1456.—Section through Embryo No. XLIII. Enlarged 8 times. *H*, Hand; *A*, auricle; *V*, ventricle; *L*, lung; *S T*, septum transversum; *P*, phrenic nerve; *U*, umbilical vein; *S*, stomach; *W*, Wolffian body; *Ov*, ovary; *Am*, amnion; *1–12*, ribs.

Expansion of the Body Cavity and Obliteration of the Extra-Embryonic Cœlom.—After the pleural and pericardial cavities are separated from each other it is very easy to follow their further development. In embryo II., Fig. 1459, the heart is still upright, and a transverse section of it is also transverse to the lung. The pleural cavity lies wholly on the dorsal side of the pericardial (Fig. 1444). In the next stage, as the lungs descend more and more, the heart is tilted over so that its base is toward the lung and its apex away from it, as in embryo IX., shown in Figs. 1454 and 1460. The pericardial space has now become separated completely from the pleural, although both have grown at about the same pace. From now on the pleural space grows more rapidly than the pericardial, as shown in Fig. 1461. I have a number of embryos which represent intermediate stages between embryos IX. and XXII., and all of them confirm the idea that the pleural space develops first and then is followed by a growth of the lung. Fig. 1462, which is a section of embryo No. XLV., shows a marked increase in the size of the lung, but the heart and pericardial space are of about the same size as in embryo XXII. A much later stage is shown in Fig. 1463. The scale of enlargement is only half that of Fig. 1462, and when this is considered it is again seen that the heart has not grown very much, but the lung has developed enormously.

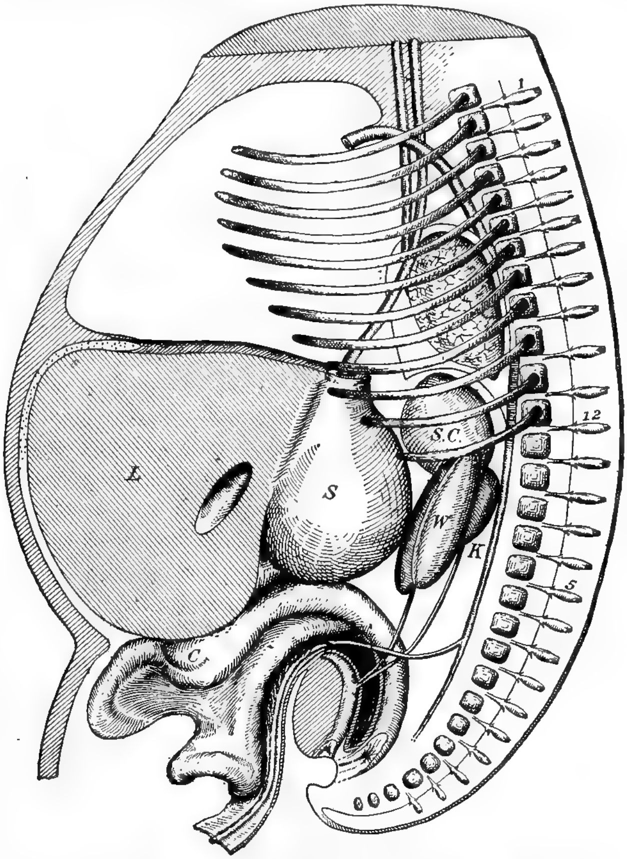

FIG. 1457.—Reconstruction of Embryo No. X. Enlarged 8 times. *1-12*, Dorsal ganglia; *S.C.*, suprarenal capsule; *W*, Wolffian body; *K*, kidney; *L*, liver; *S*, stomach; *C*, cæcum. The dotted area on the ventral side of the liver indicates the extent of the ventral mesentery of the liver.

It is therefore seen that at first the pericardial cavity is on the oral side of the pleural, then on the ventral side, and is finally enclosed by the pleural cavity growing over it.

The growth of the pleural cavity over the pericardial accounts for the location of the phrenic nerve in the adult. In Fig. 1459 the nerve passes to the septum transversum from the lateral body wall, and it is gradually separated from it by the descent of the septum and by the growth of the pleural cavity between the nerve and the body wall, thus locating the nerve in a membrane, as Figs. 1460 and 1461 will readily explain.

The expansion of the peritoneal cavity is by no means as simple. In it there are many bands and mesenteries as well as a marked shifting of the organs. With the descent of the testis a portion of it is cut off to form the tunica vaginalis.

In embryo II. the peritoneal cavity is extremely simple, as the figures show,—a simple cavity on each side communicating the one with the other by means of two openings, one above and one below the omphalomesenteric duct. Later, as the diaphragm descends more and more, the liver rotates, and its lobes soon fill the peritoneal cavity, while the intestine develops out into the core. The Wolffian body, sexual glands, and suprarenal capsule fill the dorsal side of the cavity and the rudimentary pelvis. The whole development of the intestine takes place within the cord, and finally it is drawn into the embryos when it is about 30 mm. in length. By what process this takes place I am unable to determine, but it must take place very rapidly, for I have never seen a human embryo in which it is only partly retracted. In the pig's embryo, however, I have found the stages in which the intestine is in process of retraction.

The liver now fills nearly the whole cavity, and extends down to the pelvis, and in embryo XXII. projects over the

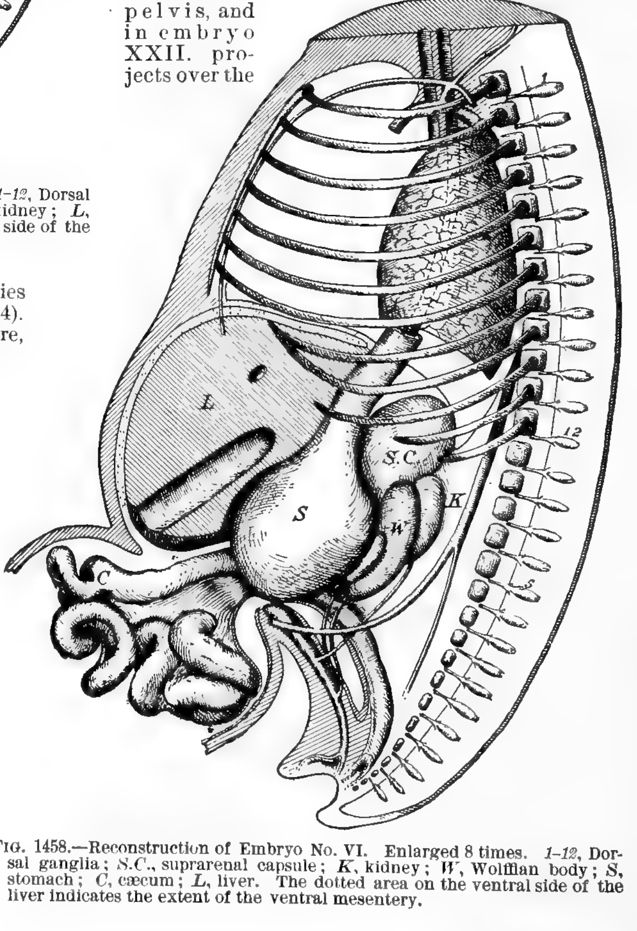

FIG. 1458.—Reconstruction of Embryo No. VI. Enlarged 8 times. *1-12*, Dorsal ganglia; *S.C.*, suprarenal capsule; *K*, kidney; *W*, Wolffian body; *S*, stomach; *C*, cæcum; *L*, liver. The dotted area on the ventral side of the liver indicates the extent of the ventral mesentery.

ovary and is in contact with the rectum. As the intestines are retracted from the cord the liver is relatively higher and higher, for the expansion of the abdominal walls is now greater below the umbilical cord than before, giving more space in this region for the intestine which displaces the liver. In embryos XXXIV. and XLVIII. the intestine has been studied, and it was found that it is still located in the ventral portion of the peritoneal cavity, as there is no pelvic cavity large enough to hold any portion of it.

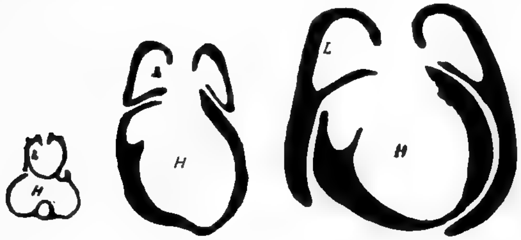

FIG. 1459. FIG. 1460. FIG. 1461.

FIGS. 1459 TO 1461.—Outlines of the Pleural and Pericardial Cavities to Show Their Relative Position and Size. Enlarged 7 times. Fig. 1459, Embryo No. II.; Fig. 1460, Embryo No. IX.; Fig. 1461, Embryo No. XXII. *H*, position of heart; *L*, position of lung.

The extra-embryonic cœlom has only a short existence, as it is already completely obliterated in embryo No. XXII. This embryo came to me in an unopened ovum, and on this account is extremely valuable for this purpose. This embryo is about six weeks old, so, reasoning from it, the union of the amnion and chorion takes place earlier than is generally believed. In embryo No. XLIII., which is about five weeks old, the amnion has expanded over the whole embryo and has nearly reached the chorion

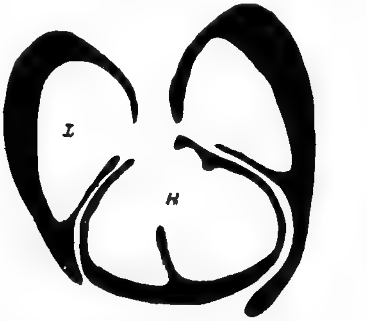

FIG. 1462.—Outline of Pleural and Pericardial Cavities in Embryo No. XLV. Enlarged 7 times.

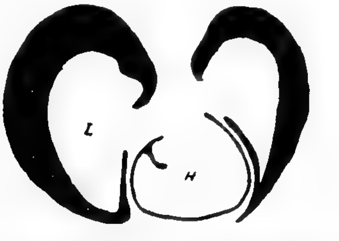

FIG. 1463.—Outline of Pleural and Pericardial Cavities in Embryo No. XXXIV. Enlarged 3½ times. *H*, Position of heart; *L*, position of lung.

The earlier stages are given in the sagittal sections. They show that the amnion is nearest the chorion at the caudal end of the embryo in the earliest stages, and soon the two unite at this point. As the embryo grows, the union of amnion and chorion extends. At the end of the fourth week the extra-embryonic cœlom is still very large; at the end of the fifth week the space between the embryo and chorion is divided equally between the amnion cavity and the cœlom; at the end of six weeks the extra-embryonic cœlom has disappeared. *Franklin P. Mall.*

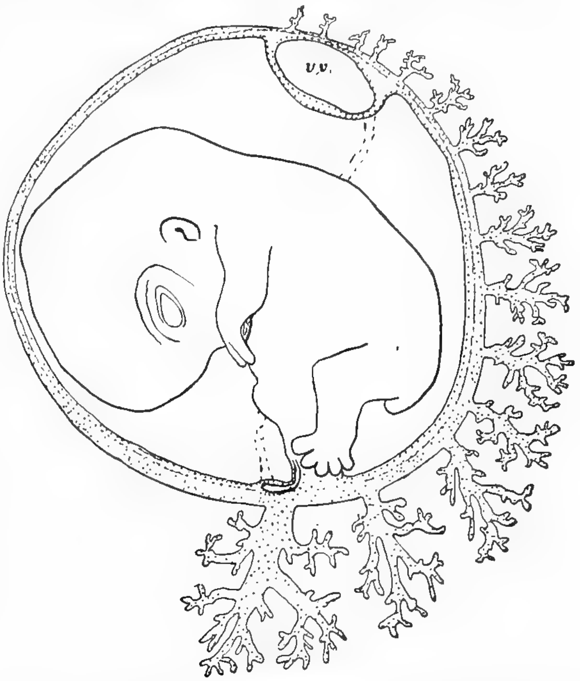

FIG. 1464.—Embryo No. XXII. Within the Ovum. Enlarged 3 diameters. The villi of chorion are outlined on one side of the ovum only. The umbilical vesicle, *u v*, has become shifted around to the dorsal and right side of the embryo. The outline is made from a photograph, and is correct in detail with the exception of the attachment of the chord to the chorion. This in reality attaches itself to the chorion immediately to the right of the embryo.

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COFFEE.—The seeds of *Coffea arabica* L. (fam. *Rubiaceæ*). Coffee itself is not official, having been replaced by its alkaloid (see *Caffeine*).

The coffee plant is a good-sized shrub or small tree, with opposite spreading or horizontal branches, and dark green, glabrous, nearly evergreen leaves. The white flowers grow in close clusters in the axils of the leaves. Farther down are the green and then the red fruits, the whole being highly ornamental. The fruit is an oblong, rounded, scarlet or purplish, slightly juicy drupe, with a thin, fleshy mesocarp, and a papery endocarp, loosely enclosing the two seeds. It is about 2 cm. long (½ to ¾ in.).

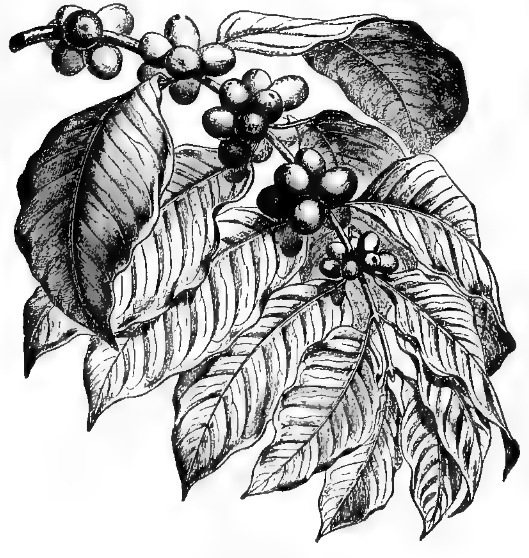

FIG. 1465.—Branch of the Coffee Tree, *Coffea arabica*, with Fruit. (Baillon.)

This shrub is a native of tropical Africa, where it grows very extensively upon both coasts, and far into the interior. It is also cultivated in most of the warm parts of the earth, especially in Java and Brazil.

Our earliest knowledge of coffee came from Arabia, where it was introduced from Abyssinia at least four hundred years ago. Its use was introduced into Europe by way of Constantinople, reaching London and Paris about the middle of the seventeenth century. Its cultivation was begun in Batavia at about the end of the same century, and in the beginning of the next it was being raised in India, Brazil, and the West Indies. The plants and the berries of these different countries present slight variations. Mocha coffee is small, plump, and dark yellow; Java larger and paler, and the Indian and American coffees larger and greenish gray or bluish gray. Mocha has the richest flavor, Java is one of the most delicate, and the West India and Brazilian kinds are coarser and less fragrant. Age, before they are roasted, improves them all.

Coffee is raised in orchards, where the trees are set in rows; trimmed and tended, they are long-lived and bear for many years. Two crops are usually produced each year. The pulp of the fruits is separated, usually by mechanical means, and the papery endocarp, when dry and brittle, broken and rubbed away. The testa of the seed is usually also absent in commercial coffee, excepting on the face, where it enters the ventral fissure.

COMPOSITION.—The most interesting ingredient, *Caffeine*, is described elsewhere. It occurs in coffee in combination with *caffeo-tannic acid*, in varying proportions between one-half of one per cent. and two and three-tenths per cent. The quality of the coffee, as usually estimated, depends only partially upon its amount of alkaloid. Of the caffeo-tannic acid, the yield is from four to five per cent. It is of the series which gives green salts with the persalts of iron. Besides these, are *fixed* oils, from fourteen to twenty-two per cent., *dextrin* from fourteen to sixteen per cent., a large amount of *albuminoid matter*, and a very minute amount of *volatile oil.* Roasting changes the character of coffee very materially, dissipating a little of its caffeine and most of its water, and forming some fragrant decomposition products not much understood. The seeds lose about fifteen or twenty per cent. in weight, and gain much more than that in volume. The sugar and dextrin are changed to caramel, and the soluble portions in general are diminished.

Unground coffee is seldom adulterated, but ground coffees are apt to be adulterated, the world over, by grains of various kinds. Of these admixtures, beans and chicory roots are the most important. It is better to purchase the whole seed than to puzzle over the mixtures. Pure ground and burnt coffee shaken in water does not immediately discolor it, as most of the imitations do. Recently, many brands of artificial "coffee," made wholly from grains and so advertised, have come into use as a warm and grateful drink, free from the nervous effects of caffeine. Many people become very fond of these products, which are used upon a vast scale.

ACTION AND USE.—The effect of coffee is in the main the same as that of caffeine, a nervous and cardiac stimulant; but it has in addition a pleasant, exhilarating effect upon the feelings, which is probably in part also due to aromatic ingredients contained in it, or developed by the roasting. It is occasionally given for sick and neuralgic headaches, and to counteract the disagreeable after-effects occasionally produced by opium; and in opium poisoning, which it mildly antagonizes by its stimulating effects upon the brain and circulation. The universal use of coffee, however, greatly restricts its usefulness as a medicine. Its excessive use, or its use by those unfortunately sensitive to it, produces wakefulness, "nervousness," confusion and incoherence of thought, palpitation, and irregular action of the heart and dyspeptic disorder. The excessive use of coffee is believed in Oriental countries to be responsible for many cases of blindness, and it certainly causes disorders of vision when sufficiently abused to disturb the nervous equilibrium.

The dose of coffee for, say, headache, is from 15 to 20 gm. (℥ ss.) in infusion, that is, a cupful made strong and "black." A fluid extract is to be had if desired.

There are twenty species of *Coffea*, natives of tropical Asia and Africa, several of which contribute a part to the total yield. One of these, *Coffea liberica*, of Western Africa, produces a larger seed, with a strong, full, but rather rank, flavor, known as Liberian coffee. Coffee leaves themselves contain caffeine, and are used as a beverage in the East. *W. P. Bolles.*

COHOSH, BLUE.—CAULOPHYLLUM. Pappoose Root, Squaw Root. The rhizome and roots of *Caulophyllum thalictroides* (L). Michx. (fam. *Berberidaceæ*). This is a perennial herb, with an erect, smooth stem, about 50 or 75 cm. (20 to 30 ins.) high, bearing a thrice-ternate leaf above the middle, and a raceme of greenish-yellow flowers at the top. The rhizome is horizontal, thick, crooked, scarred above, and covered below with numerous roots. It is a native of rich, damp woods, over most of the United States, and grows also in Japan and Manchuria. It was a favorite remedy in labor among some tribes of the North American Indians, as its vernacular names indicate.

The dried rhizome is thus described in the Pharmacopœia: "About four inches (10 cm.) long, and about one-fourth to two-fifths of an inch (6 to 10 mm.) thick, bent; on the upper side with broad, concave stem scars, and short, knotty branches; externally, gray-brown; internally, whitish, tough, and woody. Roots numerous, matted, about four inches (10 cm.) long, and one twenty-fifth of an inch (1 mm.) thick, rather tough; nearly inodorous; taste sweetish, slightly bitter, and somewhat acrid."

It contains twelve per cent. of resin and some tannin, a glucoside much resembling saponin, and a small amount of the alkaloid caulophylline.

The drug is irritating to mucous membranes, the powder being highly sternutatory. It is much like saponin in its local effects. It is recommended as a uterine stimulant, of service in parturition, and also as a stimulating emmenagogue, but there is little reliable information in regard to its action. There is no official preparation, but the fluid extract is the best form of administration, in doses of gm. 0.3 to 2.0 (gr. v.–xxx.).

Henry H. Rusby.

COLCHICUM.—*Meadow Saffron.* A genus of plants of the lily family (*Liliaceæ*), comprising about thirty species, one of which, *C. autumnale* L., yields two official drugs, namely, the corm (*Colchici Radix*) and the seed (*Colchici Semen*). As these drugs are identical in properties and use, and practically so in composition, they are considered together. The plant is a perennial herb, with a very short subterranean upright stem, arising from the apex of a corm, and having at its side another corm, younger or older according to the season.

The corm of colchicum, in the latter part of the summer, when it is usually gathered, is principally composed of that portion which has just done service in ripening the fruit. It is about 5 cm. long by 4 in width (2 × 1½ ins.), and enclosed in two brown papery coats. It is irregularly pear-shaped, rather pointed above, blunt and oblique at the base, and flattened and grooved on one side, where it clasps the new growth. At the apex is the scar or remains of the now decayed aërial vegetation. At the base, on the flattened side, is attached the new bud which is to produce the flower in the autumn, enclosed in the general coverings above mentioned. Later in the season the stem and flowers of the young bulbs form a column at the side of the old one, fitting into its flattened or grooved surface, and having the appearance of being simply a lateral bud of the older corm. During the following spring, however, the elder tuber shrivels away, and the new one, as its fruit ripens, becomes large and plump, and in its turn develops a junior for the succeeding fall.

Colchicum is a native of Middle, Southern, and Eastern Europe. It is frequent also in England, and is occasionally cultivated, for its pretty but sombre flowers, in this country. Our medical supply of the root comes principally from England and Germany. The corms are usually collected in midsummer, or shortly after, when they are the plumpest and finest looking. From this time until fall they do not change much, and if gathered when in flower would be probably equally good. They are sometimes used abroad in the fresh state; sometimes also dried whole. Usually, however, and always for this market, they are sliced and dried by the aid of gentle heat. Their quality is very sensitive to carelessness in drying. The seeds are simply collected and dried when ripe.

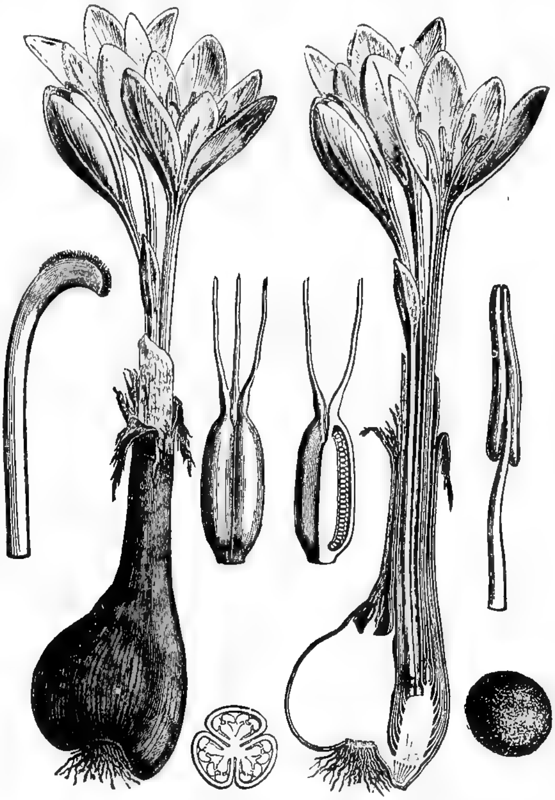

FIG. 1466.—Colchicum. Flowering plant, one-half natural size, and details of structure; also seed. (Baillon.)

Colchicum has been known as a poison since the time of Dioscorides, but as a medicine only for the last two or three hundred years. Its first admission to the London Pharmacopœia was in 1618, and thirty-two years after it was dropped, and did not reappear in it until 1788, since which time it has been in regular employment (*Pharmacographia*).

DESCRIPTION.—*The Corm.*—The transverse slices into which the corm is cut are about 3 mm. (⅛ in.) thick, and from 1 to 3 cm. in diameter, according to their position. Their cut surfaces are white or grayish white, their edges (surface of the corm) brownish yellow. In shape they vary a little; those cut from the upper part may be simply round, but those of the middle and lower portions are flattened or indented at one side, where the flower buds lie, or they may even be typically kidney-shaped. The drug is occasionally sliced vertically, when the slices will be more or less ovate, and some of them longitudinally grooved. Even the whole corms are sometimes met with. They are hard, brittle, and loaded with starch. Taste very bitter and acrid, odor simply earthy.

That which is very dark colored internally, or breaks with a horny fracture (showing too much heat used in drying), should be rejected.

The *seeds* are of more modern use, having been introduced about sixty years ago. They are sub-globular, about 2 mm. ($\frac{1}{10}$ in.) in diameter, very slightly pointed at the hilum; surface reddish brown, finely pitted and dull; internally whitish; odor none; taste bitter and acrid; texture very hard, bone-like between the teeth, at the hilum a soft caruncle.

COMPOSITION.—The corms, in drying, lose two-thirds of their weight, and when about dry consist largely of starch, in fine rounded, by mutual pressure polyhedral, and sometimes compound grains. Sugar, gum, resin, fixed oil, etc., are other common substances contained in them. The seeds also contain sugar, resin, fixed oil, etc., as incidental constituents. Both contain, as their peculiar principle, the intensely active substance *colchicine*, in small quantity—in the "root" about 0.5 per cent., in the seeds about 0.3 per cent. It is also present in the leaves. Colchicine ($C_{15}H_9[OCH_3]_3[NHC_2H_3O][CO_2CH_3]$) is a very bitter and extremely poisonous alkaloid, occurring as a yellow, crystalline powder, soluble in both water and alcohol. It yields *colchiceine*, or aceto-trimethylcolchicinic acid, in yellowish needles, soluble in alcohol. This also occurs free in the drug, and is poisonous. It is believed that these substances are not active until after oxidation has occurred in the alimentary canal.

ACTION.—The actions of colchicum, colchicine, and colchiceine differ only in degree.

All the effects are chiefly, and perhaps wholly, referable to local irritation. The skin is somewhat irritated, all mucous membranes powerfully so, sneezing, coughing, running at the eyes and nose being prominent symptoms of exposure to the dust. Its internal effects are very slow in developing, some hours usually elapsing, thus strengthening the theory of preliminary oxidation of the colchicine. Then nausea and pain in the stomach, with lassitude and salivation come on. If the dose is large enough, vomiting and purging follow, and these are characteristic of great irritation, the stools being mucous and perhaps bloody. Varying, and mostly slight, symptoms of reflex stimulation may be observed. In severe poisoning paralysis quickly follows, beginning at the lower extremities, proceeding upward, and killing by asphyxiation. It is generally believed that the latter effects are entirely dependent upon the irritation. Even if given hypodermically, the principle is excreted into the stomach and intestines, and the *modus operandi* is the same. In any case, the practical facts are that the characteristic effects of over-dosage are severe abdominal irritation and severe depression, both of which are to be avoided as much as possible in its medicinal employment. The effects upon the kidney are very irregular, depending apparently upon stimulation by small quantities, depression by larger ones. Lastly it may be noted that the irritant effects of colchicum are cumulative. They may be produced quickly by large doses, or gradually by continued small ones, so that its administration has always to be performed with watchfulness and care.

USE AND ADMINISTRATION.—All the study of the action of colchicum is devoid of therapeutic value, as no relation can be seen between the former and its therapeutic use, which is almost exclusively in the treatment of gout. We only know that gout and all its sequelæ and dependent functional disturbances are markedly relieved by the administration of colchicum, which has for very long been regarded as a specific for that disease. All cases are not equally benefited, acute and the early stages of chronic ones being much more amenable. With long-continued administration, the drug gradually loses its effectiveness, and at the same time undesirable effects become more troublesome. The desirability of cautious administration thus becomes apparent. As soon as abdominal disturbances begin, the administration should be stopped for a while.

The forms of administration are very numerous. The powdered drug is often given in doses of 0.1 to 0.5 gm. (gr. ij.–viij.). The Pharmacopœia offers us an extract of the root, dose 0.03 to 0.13 gm. (gr. ss.–ij.), fluid extracts of each, dose ♏ ij. to viij., a 15-per-cent. tincture of the seeds, dose 0.6 to 2 c.c. (♏ x. to xxx.), a 40-per-cent. wine of the root, dose 0.3 to 1 c.c. (♏ v. to xv.), and a 15-per cent. wine of the seed, dose the same as of the tincture. The presence of these two wines, of such dissimilar strength and dosage, is barbarous, and it is even to be hoped that the seeds and their preparations may be entirely dropped, or the strength of the preparations so adjusted that the dosage will be uniform. This could easily be done by alkaloidal standardization, as it is now certainly known that the two substances do not differ in kind. Colchicum corm and fluid extracts should contain one-half per cent., the extract two per cent., of total alkaloids, the other preparations proportionately with their strength. Colchicine is frequently given in doses of 0.0005 to 0.0022 gm. (gr. $\frac{1}{160}$ to $\frac{1}{25}$), colchiceine occasionally in maximum doses about half as large. Tannate of colchicine is somewhat used in doses about twice as large as those of colchicine itself. *Henry H. Rusby.*

COLCHICUM, POISONING BY.—Colchicum autumnale, or meadow saffron, order *Liliaceæ*, is a biennial plant, a native of Europe. It is not found in America. It is nearly related to veratrum. All parts of the plant are poisonous, but only the corm and the seeds are used medicinally, being most active in the second season. This plant is said to have been known to Dioscorides and to have been first used by Medea. The active principle is the intensely bitter and poisonous alkaloid colchicine, discovered by Pelletier and Caventon. Its usual form is a white or yellowish, amorphous powder; sometimes it occurs as crystals. It is alkaline in reaction, and is soluble in water, acids, spirits, ether, chloroform, and benzene. It is frequently an ingredient of quack medicines for rheumatism and gout and is sometimes put into beer. Of the preparations, those of the seeds are the more reliable. There are in the United States Pharmacopœia: an extract of the root, a fluid extract of the root and of the seeds, a wine of the root and of the seeds, and a tincture of the seeds.

Fatal Dose of the Alkaloid.—Casper quotes this to be from 25 to 30 mgm. (gr. 0.385 to 0.463). However, according to Blyth, there is a recorded recovery from 70 mgm. (gr. 1.08).

SYMPTOMS.—The poison is slowly absorbed, and the symptoms generally continue after the drug has been stopped, while relapses are not uncommon. The patient usually feels a burning pain in the gastro-intestinal tract, with great abdominal pain, griping, nausea, vomiting, and diarrhœa, although cases have been noted with no diarrhœa. The stools abound in bile and are sometimes bloody. Dysuria and hæmaturia have been recorded. The respiration and pulse are much depressed. The temperature falls, and muscular weakness supervenes. There may be cramps in the feet and calves. The brain is rarely affected. In severe cases, however, stupor occurs followed by early collapse and death. Convulsions sometimes take place. As indicated above, death does not occur at once, the symptoms in many cases lasting as long as six or seven days and even longer. If the patient recovers, it is only after a tedious convalescence. In certain cases the patient suffers from chronic diarrhœa after the other symptoms have passed away.

TREATMENT.—The use of the stomach pump is indicated, or emetics may be used, *e.g.*, ipecacuanha, zinc sulphate, mustard; or apomorphine, administered hypodermically in doses of four or five drops. Mucilaginous drinks and abundance of water are beneficial. Tannic acid neutralizes the poison and is an antidote. The bowels should be cleared out by castor oil, while the abdominal pain is quieted by morphine or opium. Heat applied to the extremities and abdomen also relieves pain. For the depression, stimulants should be employed.

Test.—If to the alcoholic solution of the alkaloid, ferric chloride be added there will result a garnet red; while if an aqueous solution be used, the color obtained will be green or brownish green. If a combination of the solid substance and nitric acid be made, a violet hue will develop. Colchicine may be extracted from a feebly acid aqueous solution by chloroform.

Post-Mortem Appearances.—Hyperæmia is the most striking of these, and has been observed in the mucous membrane of the gastro-intestinal tract, in the kidneys, lungs, articular joint surfaces, bone-marrow, brain, and cord. Degeneration of the liver has been reported. As in sulphuric-acid poisoning, the large veins are filled with thick dark-red blood. The stomach contents give an acid reaction. The pathological changes, however, are not constant.

Separation of Colchicine from Organic Matter.—Obolouski's method: The viscera are finely ground with powdered glass, and the mixture left in alcohol for twelve hours, after which the liquid is removed and the residue is washed in alcohol. This extract is heated to a temperature not above 80° C. The concentrated product is cooled and mixed with enough alcohol to equal the original quantity. The liquid is filtered and evaporated as before, and this process is repeated until, on the addition of water, there is no further separation of clots. The final residue is dissolved in water, purified by shaking with light petroleum, and at last the colchicine is extracted with chloroform. *Emma E. Walker.*

COLD, EFFECTS OF. See *Camp Diseases.*

COLD IN THE HEAD. See *Nasal Cavities, etc.*

COLD SULPHUR SPRING.—Rockbridge County, Virginia.

POST-OFFICE.—Goshen Bridge. Hotel.

ACCESS.—Viâ Chesapeake and Ohio Railroad to Goshen, thence a drive of 2 miles to springs. Hacks meet all trains.

The Cold Sulphur Springs are located in the mountains of Virginia, at an altitude of two thousand feet above the sea level. The situation is near the centre of the celebrated mineral-spring region, so long noted for the beauty of its scenery and the salubrity of its climate. Recent additions to the hotel building have greatly increased its capacity, and many improvements have been made for the comfort of guests. The location is encompassed on every side by lofty mountains of rare loveliness and grandeur, and the beautiful lawn, with its vast shade of primeval oaks, forms a picture of alluring restfulness and tranquillity. Within a few minutes' drive is the west entrance to the Goshen Pass, the gateway through which the north branch of the James River finds its way to the sea—a spot famous for its wild and magnificent scenery. The water of the Cold Sulphur Springs is clear and slightly sparkling from the gases which it contains. It has a temperature of 50° F. as it flows, and the presence of a large amount of free carbonic acid renders it peculiarly light and grateful both to the taste and to even a delicate stomach. The water has been analyzed with the following results by a chemist whose name is lost:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium sulphate	2.90
Magnesium sulphate	0.58
Aluminum sulphate	2.46
Sodium sulphate	0.65
Calcium carbonate	1.85
Magnesium carbonate	1.78
Iron carbonate	1.22
Sodium silicate	1.48
Calcium chloride	0.42
Lithium chloride	Trace.
Phosphates	Trace.
Organic matter	0.33
Total	13.67

Gases.	Cubic inches.
Sulphureted hydrogen	253.00
Carbonic acid	5.65

This analysis shows a mild alkaline-chalybeate. If the figures are correct it contains an unusually large quantity of sulphureted hydrogen. The effects of the water are tonic and sedative. It is used with good effects in diseases of the stomach, bowels, liver, and kidneys. The resort is well provided with facilities for the accommodation, comfort, and amusement of guests.

James K. Crook.

COLD, THE THERAPEUTICS OF.—Heat and cold are two relative modes of molecular motion. We call an object warm or cold when it possesses more or less molecular motion than our bodies contain. According to a fundamental law of physics, motion takes place in the line of least resistance, and since a greater quantity of motion offers more resistance than a smaller quantity, it follows that motion, unless impeded, always tends in the direction of lesser motion, or, in other words, from heat toward cold. If the animal body, therefore, comes in contact with a colder medium, it loses a certain amount of its heat; and if the surrounding temperature is sufficiently low and if it remains so for a sufficient length of time, enough heat is extracted to threaten and even to extinguish life. We may hence conclude that while cold acts as an antipyretic, it also acts as a depressant. On the other hand, when cold is applied fugitively, or for a short time, it has a stimulant and tonic effect. This duplex action of cold is demonstrated by the following observations: Liebermeister ("Beobachtungen und Versuche über die Anwendung des kalten Wassers bei fieberhaften Krankheiten," Leipsic, 1868), and Kernig (Reichert's *Archiv*, 1860) found by actual experiment that brief exposure of healthy persons to cold baths elevates the temperature, while on the clinical side it has been abundantly proven that prolonged exposure of fever patients to cold invariably reduces the temperature.

That a healthy body may have its temperature elevated by transient exposure to cold, and that a fevered body may suffer depression of temperature if exposed to cold, are facts which accord with another physical law, viz.: that action and reaction are equal. A healthy body is momentarily thrown out of its accustomed equilibrium by the aggressive force of cold, but in virtue of its greater inherent strength and resistance it is soon enabled to react on and to neutralize the influence of this disturbance, and while undergoing this greater activity its temperature is elevated. On the other hand, the fevered body possesses less resistance and is too feeble to offer much resistance to the aggressive action of cold, and hence the latter readily depresses the abnormally augmented activity of the body. Cold may, therefore, be an antipyretic or a stimulant according to the circumstances under which it acts; thus showing that, like all our therapeutic agents, its effects are controlled by the dose and by the length of time during which it is administered. Additional cold also contracts and condenses bodily tissue, and thus incidentally it has the power of contracting blood-vessels—a property of considerable therapeutic importance.

Physiologically it may be said then that cold acts (1) as an antipyretic; (2) as a tonic or stimulant; and (3) as a contractor of the blood-vessels, by which means it lessens the supply of blood.

METHODS OF APPLYING COLD.—It has already been shown that the effects of cold depend on the manner in which this agent is applied, and it is therefore necessary briefly to consider the different modes of its application together with the physiological effects of each.

Wet-Sheet Application.—A cotton or linen sheet is wrung out of water having a temperature of 80° or 90° F.; it is then wrapped around the patient's body, and is allowed to remain for two, three, or four minutes. If the patient is in a feeble condition, vigorous friction must precede and follow the application of the sheet. The temperature of the water may be gradually lowered as the patient becomes accustomed to the influence of cold. Used in this way the wet sheet takes the place of a cold bath in a certain class of invalids, relieves fatigue and nerve depression, and invigorates vital energy.

Spinal Bath.—Water at a temperature of 80° F. and gradually cooled is poured from a jug or can, or pressed from a large sponge, along the spine as the patient sits on a stool in the bath tub. It is to be continued for from five to ten minutes at a time and may be repeated once or twice every day. In a short time the patient will be able to bear the water entirely cold. The spinal cord, as well as the peripheral and visceral nerves, is stimulated, and it is claimed that the abdominal organs are influenced favorably.

The Pail Douche.—This method of bathing consists in throwing three or four bucketfuls of cold water over the front and back of the patient's chest while he is sitting in a bath tub. The exact temperature of the water is to be graduated by the feelings of the patient. A vigorous rubbing with a dry, coarse towel follows the douching. This form of bath is available only for those who possess a rather vigorous constitution, but in such cases it acts as a powerful invigorator.

The Spray Douche.—No other form of bathing produces such powerful stimulation as that of the cold spray douche. The effects of the cold are enhanced by the mechanical impact of the water on the body, and they vary, of course, in accordance with the size, force, direction, and duration of the column of water which is employed. The size of the latter may be from one to three inches in diameter and may fall from a distance of from a few to ten or twenty feet; or it may be directed in a small stream at right angles against the patient's body. The stream may also be broken up into fine jets and allowed to fall on the patient's body, or be directed against it at an angle. It may be used alternately with hot or tepid water, and in beginning to use it, in cases in which the power of vital resistance is not very pronounced, it is a good plan to employ water with a temperature of about 80° or 85° F. and gradually lower it to the desired point of coldness. If cold water is used from the outset in the treatment of such persons it is best first to spray the extremities and then the trunk. In persons possessed of robust reaction the spray should be allowed to fall from the desired height on the head, shoulders, and back, and should be continued for from one to three minutes. It is important that it should not be continued for too long a time, for if it is, the patient will fail to obtain its full exhilarating property.

The Plunge Bath.—In this form of bathing the person jumps into a pool or tub of cold water, remains there for a few minutes, and is then dried and rubbed with towels. The effects of such a bath are similar to those of the douche, although not so pronounced. The plunge bath is the final stage of the Turkish bath, and to it the latter owes much of its agreeable and stimulating property. As in the douche, a sudden chilliness, a deep inspiration, and a roughening of the skin are some of its prominent effects, which in a few minutes are followed by a sense of warmth and exhilaration.

The Prolonged Bath.—Here the patient is immersed in a tub of water the temperature of which ranges from 65° to 70° F., or slightly lower. It abstracts heat in febrile diseases, soothes the irritable nervous system, and provokes sleep. The duration of a bath of this kind is governed by the influence which it exerts on the fever. This is its chief object. If the fever falls to the level of 102° F., or still nearer the normal, the bath is discontinued and the patient is returned to bed. This method of treating fever was introduced by Currie and Brand about a century ago, but fell into disuse some time later. It was revived by Liebermeister, von Ziemssen, and others in Germany, and has latterly found strong advocates in America, among whom are Wilson, Tyson, and Baruch.

Ice Applications.—The application of ice to the human body is the most concentrated form in which cold may be employed. Its physiological action, which differs somewhat from that of the other forms already described, has been investigated by various observers. Thus, Mosler (*Virchow's Archiv*, 1873, Band lvii., 1) found that by applying an ice bag over the spleen of a dog its length diminished from 17 to 14 cm., and its breadth from 5 to 4.6 cm., in the course of an hour. Dr. Schlikoff (*Deutsches Archiv f. klin. Med.*, Bd. xviii., p. 577) made a series of observations on man, in the course of which the thermometer was introduced into various cavities of the human body, and ice bags were applied to the exterior. For example: 1. A thermometer being placed between the gum and the cheek, and an ice bag applied to the outside, the temperature fell 5.1° C. in one hour. After removing the ice bag, the temperature returned to the normal in half an hour's time. 2. When the thermometer was held in the hollow of the hand, and an ice bag applied to its dorsum, in seventy minutes the temperature fell 5.8° C.; an hour after the removal of the ice bag the temperature had not attained its original elevation. 3. In an empyæmic patient the thermometer was introduced into the pleural cavity firmly against its inner wall, and the ice bag was placed immediately over it; in an hour the temperature fell 3.7° C. The original temperature was regained in fifty minutes after the thermometer was removed. The thickness of the thoracic wall was 3.2 cm., which gives the distance between the bulb of the thermometer and the ice bag. 4. Introduction of a thermometer into the intestine through an intestinal fistula, and the application of an ice bag over the abdomen reduced the temperature 2.3° C. in the course of half an hour—the distance between the thermometer bulb and the ice bag having been about 4 cm. 5. When the thermometer was placed in the vagina, and the ice bag over the pubic arch—the distance between the two being 7 cm.—the temperature fell nearly 1° C. in a little less than an hour and a half. 6. Introducing a thermometer into a fistulous passage leading to a carious tibia—the soft parts being inflamed, thickened, and œdematous—and placing an ice bag over the same, reduced the temperature 0.5° C. in eighty minutes. The distance between the thermometer and the ice was about 4 cm.

These experiments demonstrate, therefore, that when cold is employed in the manner indicated it has the property of diminishing the volume of bodily organs, reducing temperature very actively, and showing sufficient penetrating power to influence deep-seated organs.

THE THERAPEUTIC APPLICATION OF COLD.—Next in order will be considered the various affections in which the remedial value of cold is indicated.

Nervous Debility.—In cases of nerve exhaustion without serious change in any of the vital organs,—a condition often found among men of intellectual pursuits,—the douche applied daily is a most valuable adjunct in the treatment. If possible the douche should be commenced during warm weather, and after being begun it should be used every day throughout the year.

Hemorrhoids.—When ice in a bag or wrapped in a towel is applied in the early stage of this affection it will give relief quickly. When the disorder is of several days' standing, moist heat is probably preferable; although it is a good plan to test the influence of cold first.

Acute Orchitis.—Surrounding the inflamed testicle with ice bags, or allowing a stream of ice water to flow on it, will frequently cut short the pain and relieve the swelling.

Acute Tonsillitis, Diphtheria, and Croup.—Application of cold to the neck in these diseases, either in the form of ice bags or in that of compresses, preferably the former, has a most comforting and quieting influence on the patient. It allays fever and pain, and prevents infiltration of the cervical glands.

Measles.—In strange contrast to the medical teaching of half a century ago, that patients suffering from measles should be kept in a warm room, remain unwashed, and be protected from all cold air draughts,—it is now a well-established fact that the application of cold externally in one form or another, and the administration of an abundant supply of cold water internally, is a most serviceable method of treating this disease. When the fever is mild, sponging of the whole body with cool water will suffice to reduce the temperature. If the fever rises to 103° or 104° F., the cold pack is to be applied, or the patient is to be tubbed. In case there is swelling of the glands of the neck, as often occurs, the application of an ice bag over the tumefaction will have a counteracting effect.

Scarlatina.—No other exanthematous disease is so prone to develop a high temperature as scarlet fever, and in no other are the remedial effects of cold applied externally more marked. In mild cases cold sponging is all that is necessary. When the temperature rises to 105° or 106° F., and is accompanied by stupor and delirium, when the rash is dark and not well marked, and when the urine is loaded with albumin, nothing seems to be more effective in reducing fever, in quieting stupor and delirium, and in bringing out a well-marked eruption than a cold tub bath or the cold pack. For the throat affection the ice bag is to be applied externally to the neck, from the beginning of the attack, and the patient is to be encouraged in holding small pieces of ice in the mouth until they are dissolved. Cold water is to be allowed as a drink.

Cholera Infantum.—In affections of this kind, when the diarrhœa becomes an almost continuous serous discharge, when the abdomen and head are very hot and the extremities are cold, coupled with a tendency to coma, an ice bag or two applied to both the abdomen and the head, and hot-water bags or hot poultices to the arms and legs, are frequently followed by the very best results.

Cerebral Congestion and Cerebro-Spinal Meningitis.—In these diseases the application of a number of ice bags to the head and neck is a most useful therapeutic measure. The action of the cold thus employed is enhanced by the application of mustard or hot water to the extremities.

Sun-Stroke; Heat-Stroke.—The former is merely an intensified form of the latter, and both conditions require the same treatment. The patient should be stripped, laid on a canvas cot, covered with a sheet, and a stream of iced cold water allowed to play on his whole body, while at the same time the head is packed in ice. The stream of water may come from a hose or from the mouth of a large can. When the high temperature is reduced and approaches the normal point, his body should be wrapped in warmed woollen blankets, while the application of cold to the head is to be continued.

Typhoid Fever.—The use of cold in various forms and at different temperatures is one of the most approved methods of combating typhoid fever. In mild cases of this disease, or in cases in which the general tub bath is not well borne, frequent or almost constant sponging of the whole body with cool or cold water, slightly acidulated with vinegar, is usually sufficient to restrain the temperature and to reduce it to a proper point. In case the fever makes a stubborn resistance the patient should be placed in a tub bath the temperature of which may range from 60° to 80° F. If it is well borne, it is best to begin with a bath temperature of 65° or 68° F. Sometimes it is a good plan to begin with a bath temperature of 80° and gradually lower it to 60° by the addition of ice water. The patient should remain in the bath for five, ten, or twenty minutes, or longer if necessary, to reduce the fever to 102° F.; and the bath is to be repeated as often as the temperature rises above the latter point. Between the baths ice bags should be used over the abdomen and head, and in cases of intestinal hemorrhage or of marked tympanites the ice bags should be applied continuously to the abdomen. Placing an ice bag over the region of the heart also serves to allay the irritability of that organ. In cases in which tubbing is inexpedient and the temperature remains high the cold pack may be resorted to, or the patient's body may be rubbed with small lumps of ice. After the patient leaves the bath his body must be rubbed dry and wrapped in a warmed blanket in order to secure good bodily reaction.

Cold water should also be freely used internally. This is of great importance. It should be given systematically whether the patient asks for it or not.

Appendicitis.—Application of the ice bag over the right iliac fossa is a useful measure to afford relief in this affection. It is superior to the hot poultice, although in some instances the alternate application of the two is beneficial. When vomiting is present the patient should be allowed to dissolve small pieces of ice in his mouth.

Acute Rheumatism.—Professor Esmarch, of Kiel, as far back as 1861, drew attention to the great utility of ice locally applied to the involved joints in the treatment of acute articular rheumatism. The results, as compared with those derived from the application of heat, blankets, blisters, etc., were most striking both in regard to the shortening of the attacks and the diminution of the pain. Dr. Wilson Fox (*Lancet*, vol. ii., 1871) reported two cases of rheumatic fever in adults, one with a temperature of 110° F. and the other with a temperature of 107° F., which were treated with cold applications and both made prompt recoveries. The ice was placed on the chest, abdomen, and along the spinal column, and iced water was rapidly poured over the patients' bodies at the same time.

From all the practical evidence at our command there is no more reason why cold should be contraindicated in acute rheumatism than it is in any other acute inflammatory disease; and the day is not far distant when it will be employed as frequently in this disease as it is now used in typhoid fever.

Acute Pneumonia.—The principal indications in the treatment of acute pneumonia are: (1) reduction of the volume of blood in the lungs, (2) reduction of fever, and (3) support of the function of the heart. From his own experience, the author believes that all these indications are fully met by the application of ice to the chest immediately over the seat of inflammation in both croupous and acute catarrhal pneumonia, and that this agent checks the extension of the inflammatory process, constricts the pulmonary capillaries, promotes resolution, disperses the products of exudation, reduces fever, strengthens the pulse, alleviates difficult breathing, abates pain in the chest, and gives general comfort to the patient.

The number of ice bags which are to be applied in any case depends on the degree of fever which is present and on the size of the area which is inflamed. If the fever is not very high and the inflamed area small, one or two bags will answer. If the fever is high and the involved area large, as many as eight or ten may be applied, it being always borne in mind that the head should monopolize one or two constantly. The length of time during which they are kept on also depends somewhat on the range of fever. If the temperature falls near the normal, it is good policy to remove some, but not all, of the ice bags, unless the crisis is at hand. If they should be removed too early and before the crisis-period, the temperature will rise again, and as a rule it is brought down with greater difficulty the second than the first time.

Acute Pleurisy.—There is no other external application that will relieve the painful breathing of acute pleurisy more quickly than that of the ice bag; and when this is coupled with suitable internal treatment it will soon cut short the disease.

Acute Pericarditis.—In this affection the ice bag, when applied directly over the heart, gives relief to the pain, reduces fever, and quiets the action of the heart.

Hæmoptysis.—Whether hæmoptysis is of pulmonary or of cardiac origin, it is always benefited by the application of one or two ice bags to the chest. It is important, of course, that a differential diagnosis in regard to the source of the bleeding should be made as soon as possible, so that each case may be treated with appropriate internal remedies in connection with the external use of ice.

Pulmonary Phthisis.—The cold douche has been used in Germany and in this country in the treatment of this disease, and is highly recommended in cases in which the temperature of the body is at or very near the normal point. The patient, previous to the bathing, is rubbed with a dry coarse towel, and is then exposed to the douche for ten or fifteen seconds, or even longer, after which he is again rubbed until the skin becomes red. He is then allowed to take a brisk walk for a short period, after which he takes a rest. This is repeated every day. In cases of acute phthisis one or two ice bags should be applied over the affected area and retained there. It is very good practice to allow phthisical patients with irritable hearts to wear an ice bag continually over the cardiac area. It quiets the heart and checks the temperature.

Thomas J. Mays.

COLECTOMY, COLOSTOMY, COLOTOMY. See *Colon.* (*Surgical.*)

COLEMANVILLE MINERAL SPRINGS.—Cumberland County, Virginia.

Post-Office.—Lucyville. Hotel and cottages.

This resort has recently come into notice. Under its enterprising management it gives promise of becoming a vigorous rival to some of the older Virginia spas. The location presents many pleasing features of climate and scenery, but its chief attraction is in the great number and variety of mineral springs in the neighborhood; these are eighty-seven in number. We present the following analysis of two of the best-known springs, made in 1894 by William H. Taylor, state chemist:

Spring No. 7.

One United States Gallon Contains:

Solids.	Grains.
Calcium bicarbonate	7.93
Magnesium bicarbonate	5.52
Iron bicarbonate	Trace.
Lithium bicarbonate	Trace.
Potassium sulphate	0.22
Sodium chloride	1.87
Potassium chloride	0.04
Magnesium chloride	0.45
Silica	3.38
Total	19.41

Spring No. 19.

Iron bicarbonate	1.69
Calcium bicarbonate	1.52
Magnesium bicarbonate	1.15
Sodium bicarbonate	1.24
Lithium bicarbonate	Trace.
Potassium sulphate	0.13
Sodium chloride	0.15
Potassium chloride	0.05
Silica	2.45
Total	8.38

The water is used in general debility, gastro-intestinal disorders, and derangements of the liver and kidneys.

James K. Crook.

COLIC, INTESTINAL.—Intestinal colic is irregular and fluctuating pain in the intestines, occurring mostly in seizures of variable duration and at varying intervals, and usually without inflammation, fever, or discoverable organic change. Enteralgia is a term sometimes applied to colic, but more often to a neuralgia of the intestines without spasm. The terms are frequently used interchangeably, and no discussion of either could fail to include, in some measure, both subjects.

Etiology.—Colic attacks both sexes, is very rare after the middle period of life, but affects all ages up to that point, and is especially frequent in infancy. It is due to many causes, and arises under a great variety of circumstances. *Indigestion* causes a majority of all the cases. Irritating, indigestible, and decomposing food in the intestines causes pain directly, and often provokes spasmodic and painful peristaltic action, while gas is rapidly formed wherewith the bowel is distended to the extent of producing suffering. A diarrhœa may be set up and expel the offending material, when the colic ceases.

In some cases of mild intestinal indigestion there are frequent slight colicky pains without other symptoms.

Constipation may induce colic in the large intestine. The colon becomes distended with hard, dry fæces, by which, after a variable period of tolerance, it is stimulated to severe spasmodic efforts to evacuate itself, with the result, usually, of sharp pains. Various *foreign bodies* in the intestines induce pain, as worms, irritating medicines, the indigestible portions of fruits and vegetables, intestinal concretions, and unnatural objects swallowed by accident or caprice. Collections of *gas*, when large or imprisoned so as to resist peristaltic force, cause the severest colic, especially in infants. Even the movement of moderate quantities of gas through the intestine is sometimes painful. *Cold drinks* in large potations, ices and ice cream, may cause colic, and *cold-catching* and chilling of the surface may induce it by congestion of the abdominal organs and disturbance of the nervous system. *Rheumatism* and *gout* may attack the muscular and nervous tissues of the intestine and induce pain.

Alcoholic excesses are sometimes followed by colic. Probably the alcohol simply induces indigestion, which in turn causes the colic. This view seems the more plausible since in many of these cases there are, with the colic or preceding it, vomiting, abnormal thirst, hiccough, and constipation.

Malarial poisoning occasionally produces regularly recurring paroxysms of enteralgia, the periodicity corresponding with that of intermittent fever. *Lead poisoning* is a prolific cause of colic in adults, and poisoning by *copper* induces it in a few cases. *Dysentery* and other inflammations of the colon and rectum are attended with colicky pains, more or less severe and frequent. *Syphilis* is said occasionally to produce nocturnal enteralgia. *Invagination* of the intestine, *hernia*, and *peritonitis*, local and general, may cause interrupted pains in the intestines. Colic is sometimes a true *neurosis*, and is due to the ordinary causes of neuralgia and hysteria. Depressing *emotions* may cause it, and debility from chronic disease or other cause tends to the easy occurrence of intestinal pains.

Symptoms.—The symptoms of colic vary in degree and character. An attack, especially when due to digestive disturbances, may be preceded by such symptoms of so-called biliousness as anorexia, sense of oppression, or weight in the stomach, eructations, and possibly nausea and vomiting. All the forms of colic, and nearly all forms of intestinal pain, are characterized by more or less fluctuation and periodicity in the suffering. The paroxysms last from a few seconds to several minutes, and are followed by remission or complete cessation of pain lasting from a few minutes to many hours. Although colic may occur in any part of the intestinal canal, unless it is in the rectum, the patient usually refers the pain to the neighborhood of the umbilicus, whichever portion is involved. The pain may be felt in other regions of the abdomen, especially in the hypochondria if the disease is in the large intestine; but in some cases of colitis the pain is complained of at the umbilicus exclusively. In non-inflammatory cases pressure on the abdomen frequently lessens the pain.

Colic has all shades of variation in degree of pain. Sometimes so mild as to disturb the patient but little; so slight as not to prevent his moving about and attending to the duties of life; it may be so severe as to cause him to writhe and groan, bend his body forward, plunge his fists into the abdomen, or lean forward over the back of a chair, or roll about in an agony of torture hardly exceeded in human experience. Patients characterize the severer pains by a variety of terms, according to individual fancy, as griping, twisting, cutting, and tearing. The abdomen may be variously distended with gas, or it may be quite flat, so flat that in a thin patient the spinal column may be easily felt from the front. In colic due to indigestion much flatus may exist, distending the abdomen and giving evidence of its active movement during a paroxysm by frequent and loud borborygmi. In the absence of distention, the peristaltic movements and knotting of the intestine by the spasm thereof may usually be felt through the abdominal wall at the moment of suffering. During the paroxysm the intestine is observed to be in strong movement, or in hard masses or nodular tumors, but during an interval the abdomen is soft and without motion. In attacks of pain with inflammation, and sometimes without it, the abdominal muscles may be tense, and the cremaster may be contracted. Frequently with colic there is tenesmus.

The temperature in an attack of ordinary colic is rarely elevated, fever is quite unusual, while the extremities and surface are often cold and clammy with perspiration. The pulse is not usually accelerated; frequently in a paroxysm it is abnormally slow, increasing its rate immediately afterward.

In infants, who furnish a large majority of all cases of colic, the symptoms during an exacerbation are: repeated or increased crying, refusal to nurse, entirely or but for a moment at a time, flexing the legs and thighs, and bending the body in multifarious contortions.

A number of other symptoms may attend those of colic, varying with many circumstances and conditions; thus there may be nausea and vomiting, dyspnœa and a sense of compression of the chest, faintness, tremor, and vertigo.

In hysterical colic considerable cutaneous hyperæsthesia may be present, causing light pressure and palpation to be quite painful, while firm and deep pressure gives comfort. Other evidences of plumbism nearly always attend lead colic. Among these are anæmia, cachexia, constipation, anorexia, a bad breath, the blue line of the gums about neglected teeth, and paralysis of the extensor muscles in the forearm.

Pathology.—For the occurrence of intestinal colic there must exist either an irritation or hyperæsthesia of the intestine, or both. There is reason to think that many cases of enteralgia—intestinal pain without spasm—are pure neuralgias of the sympathetic nerves of the abdomen, otherwise neuroses.

The constipation, scantiness of the urine, and retarded pulse, often observed in colic, particularly that from plumbism, are evidences of nervous disturbance as veritable as is pain.[1] The pneumogastric nerves are proven to have relations with the muscular fibres of the intestine, and may be presumed to play some part in their pathology. Electrization of the pneumogastrics causes contraction of the muscles of the intestine. Galvanization of the solar plexus induces contraction of the small intestine. Irritation of the fifth nerve at certain points, and of the medulla oblongata, causes muscular movement of the stomach and intestines.

Colic is in most cases the result of sharp peristaltic contraction of the intestine in its efforts to free itself from some irritation. The contractions are regularly peristaltic, or irregular, erratic, and ineffective toward moving the contents of the bowel forward, but rather preventing it. In severe cases, with agony from muscular contractions, often no evacuation results until the system is brought fully under the influence of opium to stop the pain, when free dejections take place.

In dysentery and other inflammatory states of the colon and small intestine, the colicky pains experienced are probably due in most cases—or chiefly due—to normal peristalsis in a tender intestinal tube. But the inflammation of the intestine probably sometimes induces spasm in other parts than at the seat of disease.

In lead colic the ganglia and filaments of the sympathetic nerves of the abdomen have been found enlarged by thickening of their connective tissue. The sheaths of some of the small vessels of the mucous membrane have likewise been found in this condition.

Diagnosis.—Intestinal colic is to be discriminated from hepatic, renal, ovarian, and uterine colic; from gastralgia, peritonitis, and other inflammations within the abdomen; from intussusception, hernia, and other obstructions of the intestines; from spinal disease, aneurisms of the abdominal aorta, and from labor pains.

From hepatic colic it is distinguished by the relatively long continuance of the former, by the location of the pain with tenderness at the epigastrium, by the relatively continuous character of the pain, and by occasional icterus.

In renal colic the pain is in the region of one ureter, and continues usually much longer than a paroxysm of intestinal colic; pains shoot down into the groin and pubic region, which perhaps never occurs in intestinal colic; and there is a frequent desire to urinate, and bloody urine may be passed after a paroxysm, if not during its continuance. Gastralgia of slight degree at times resembles intestinal colic, but the pain is usually higher in the abdomen than in the latter affection, and has such positive relations with the gastric functions as to make the diagnosis usually easy. Nearly all cases of severe epigastric pain, usually called gastralgia, are cases of gall-stone colic.

Peritonitis rarely occurs without some fever and a rapid pulse, although it may exist without either. The patient is quiet, the abdomen is tender in some degree, and there are no moving about and pressing the abdomen for comfort as is seen in intestinal colic. But it is hardly safe to regard all cases of tenderness of the abdomen as inflammatory, since in lead colic—uniformly unattended with inflammation—pressure may cause pain. On the other hand, in some cases of intestinal ulceration gentle and firm pressure gives a sense of relief.

Strangulated hernia has been mistaken for colic, the pain being paroxysmal and referred to the umbilical region. In a case of colicky pains in the abdomen, about which there can be doubt as to its seat and character, careful examination for hernia, in the several regions of its possible occurrence, should never be omitted. Intussusception and twisting of the gut have been more than once mistaken for flatulent colic. In these conditions there are usually complete intestinal obstruction and some vomiting, at first of a simple character, but later consisting of stercoraceous matter, with complete absence of evacuations from the bowels, except in some cases of intussusception in which there may be voided a few small and possibly bloody stools.

There is no certain way to diagnosticate the presence of worms as a cause of colic, except to see them. If they are suspected, the test of treatment may be made with some anthelmintic medicament.

The pain of abdominal aneurism is less severe and paroxysmal than that of colic, there is no movement of gas in conjunction with the pain, nausea and vomiting are absent, as also is a tendency to diarrhœa. Auscultation will readily determine the question of aneurism, and the application of this test should never be neglected in any case of persisting abdominal pain in an adult.

Prognosis.—In the main the prognosis is favorable. Deaths have occurred from rupture of the intestine due to gaseous distention. An occasional death of an infant with convulsions following upon colic seems to be due to this event, but probably in most such cases the colic, the convulsions, and the death are results of some common cause. Severe colic may lead, in infants, to intussusception.

Treatment.—The first theoretical indication in colic is to stop the pain and spasm;—after that, the cause is to be removed, if possible. The most practical treatment for the greatest numbers of cases of intestinal colic is free evacuation of the colon by an enema. In cases of moderate severity benefit may be expected from mild opiates and carminatives, warming agents for the stomach and bowels, like cardamon, mint, anise, gaultheria, aromatic spirit of ammonia, compound spirit of ether, and chloric ether. Of the opiates the best for such cases is paregoric.

For severe attacks quick relief is demanded, and a prompt remedy should be chosen. Chloroform and ether by the stomach and by inhalation, and morphine hypodermically, fulfil the indication best. For prompt and certain action nothing takes the place of hypodermic injections of morphine. One moderate dose is usually sufficient. In some intense cases the pain is slow to yield to even repeated doses, and caution is necessary to avoid the introduction of a quantity sufficient to bring on fatal narcotism—a thing that has been done more than once. The morphine should be supplemented by the internal administration of such remedies as chloroform, ether, compound spirit of ether, and chloric ether, and by inhalation of anæsthetics if necessary.

In cases due to indigestion the alimentary canal should be evacuated soon. Next to quieting agents for the pain, mild cathartics and enemata are the most widely useful medicines in colic. Where there is a tendency to the extensive development of gas in the intestines from indigestion, antifermentatives and aids to digestion may be used, as, for example, the sulphites and hyposulphites, the salicylates, salol, the preparations of pepsin and pancreatin, and the various stomachics and carminatives. In lead colic the first medicine is opium; the system should feel the effect of it before the attempt is made to produce catharsis. One of the best cathartics is croton oil in small doses, but other vegetable cathartics and the salines may be used with good effect. Enemata of mistura asafœtidæ may relieve flatulence—an excellent measure for children—and a long catheter passed up the rectum as far as possible may give exit to volumes of gas. This latter result is more likely to ensue if the body can be to some extent inverted so that the pelvis is much higher than the shoulders, with the spine uppermost. If gaseous distention is so extreme as seriously to threaten the integrity of the intestine, or to portend shock or death from interference with vital organs, it is justifiable to puncture the intestine through the walls of the abdomen with a trocar of small diameter and to evacuate some of the gas if possible. This operation, not devoid of difficulty and danger, may yet, in a perilous meteorism—a most rare occurrence—offer to the patient the lesser of two dangers to life. If the surfaces of the body and extremities are cold they must be kept warm by clothing, a hot bath, or a liberal use of bottles of hot water or some other heated thing. Mustard sinapisms and hot turpentine stupes to the abdomen frequently somewhat relieve slight colicky pains; they are of small consequence for severe pain. Stupes or dry flannels over a part need not be removed or changed for reheating; they may be kept continuously hot by a succession of hot plates laid against them. Where inflammation exists, particularly if the peritoneum is involved, the incessant contact of a hot dressing constitutes one of the best measures of treatment.

The colic of infants requires treatment on the same general principles as that in adults. The cause, which is usually some form of maldigestion, must be discovered and corrected if possible. Infants who are predisposed to attacks sometimes experience much benefit from a protracted slight effect of belladonna or the bromides, or both. For the relief of an attack of colic a few drops of whiskey or brandy, or the compound spirit of ether well diluted with water, slightly sweetened, may be given, or, these failing to give relief, the camphorated or the deodorized tincture of opium may be resorted to with caution. At the same time the mixture of asafœtida may be injected into the rectum. Frequently no permanent relief is experienced from these or any measures till the bowels are freely evacuated, and this should be the first consideration when, as is usually the case, there is reason to think that the intestine contains irritating substances.

Norman Bridge.

[1] J. W. Begbie, Reynolds' Syst. Med., vol. iii., p. 133.

COLITIS, MUCOUS.—A distinction is frequently made between mucous and membranous colitis; it will appear further on that this distinction cannot well be maintained, and it is proposed to treat the subject under the common heading of mucous colitis.

The peculiar group of symptoms variously termed mucous or membranous colitis or enteritis, pseudo-membranous enteritis, fibrous enteritis, etc., constitutes an affection pre-eminently of the female sex. According to Litten, eighty per cent., according to Kitagawa, as much as ninety per cent. of all observed cases occur in women. It is found, however, not infrequently in men and even in children. Löwenstein reports the case of a boy three years old.

The women suffering from mucous colitis show, as a rule, well-marked, more or less extensive neurotic or hysterical stigmata. The same holds good for children. The men are usually distinctly neurotic or hysterical.

Of late years the clinical symptoms and the pathology of this disease have been the subject of much discussion, though nothing essentially new has been brought out since the masterly essay of the late Dr. Da Costa, in the *American Journal of the Medical Sciences* for 1871. The more important clinical symptoms of mucous colitis may be briefly summarized as follows:

Pathognomonic for the affection are the peculiar evacuations from the intestines. Preceded by more or less pain of a colicky character and of varying duration, masses of a grayish white, somewhat translucent, substance are evacuated. These masses vary in quantity and in form; at times they appear as shreds, single or netted together; sometimes as balls and lumps; again as membranes or as longer or shorter apparently solid ropes, or again in tubular configuration representing complete casts of segments of the gut. In some cases only a comparatively small quantity is passed; frequently, however, the mucous masses are very abundant and sometimes appear in really enormous quantities. Fæces are as a rule rarely passed with these masses, which form practically the sole constituent of the stools. When floated and disentangled in water it becomes apparent that in every instance these masses are rather membranous, and are rolled up or balled together to resemble lumps, tubes, ropes, etc. Chemically this substance presents all the characteristic reactions of mucin; though sometimes and inaccurately called fibrinous, no fibrin has as yet been found whenever careful chemical examination was made.

Microscopical examination shows, besides mere traces of fæcal matter, the characteristic striated thready mucoid substances intermingled with innumerable epithelial cells either discrete or else in connected layers. It is of importance to note that leucocytes are never found in great numbers, but occur rather singly here and there, thus offering no suggestion of inflammation or suppuration.

With the discharge of these mucous masses the colic is usually relieved. In rare cases one single attack ends the affection. As a rule the seizures occur again and again. There may be intervals of weeks or months between the attacks, during all of which time the patient may feel entirely well. The attack itself may last for days or weeks or even months. A single attack of colic may occur each day, or there may be several if not numerous ones, so that the patients are often convinced that they have diarrhœa or dysentery.

The pain is variously described as griping, burning, cutting, pressure, etc. Not infrequently there is considerable tenesmus. The pain is located in some portion of the colon, most frequently in the sigmoid flexure or in the cæcum. If in the latter place, it frequently gives rise to a suspicion of appendicitis in the mind of the patient as well as of the physician. From these points of origin the pain radiates toward various parts of the abdomen, most often toward the umbilicus and epigastrium; quite frequently also down one or the other thigh, especially down the left. The abdomen may be more or less distended, but is mostly quite normal and soft. Fever is never present in uncomplicated cases. Nausea is often complained of during the attacks, but vomiting is rare.

Enteroptosis is often associated with this disease, and gastric hyperacidity is not an infrequent concomitant. Characteristic of uncomplicated cases is the fact that in the intervals between the attacks there are no intestinal disturbances, and the patient, aside from possible neurotic complaints, seems quite normal. A great number of this class of patients attribute their pains and discomforts to gastric and intestinal indigestion. They endeavor to establish a connection between the attacks of colic and indiscretions in diet. As a consequence they soon come to dread almost every sort of nutritious food, and, living on an entirely insufficient and irrational diet, lose rapidly in weight and strength, without their local condition being at all benefited. On the contrary, it can be easily seen that in all these cases, with the loss of flesh owing to insufficient nutrition and the accompanying increase of neurotic conditions, the malady becomes steadily worse.

As regards the pathology of this disease, there are still some differences of opinion. Some few still maintain that mucous colitis is an organic lesion of the colon, a true inflammation, a catarrhal or even an ulcerative process, and that besides an abnormally abundant secretion of mucus, portions of the mucous lining are detached and voided in the form of shreds and membranes. There are, however, serious, and it seems to me, conclusive objections to this view. It is true that dead-house material, by means of which one may study this class of cases, is very scanty indeed. Those cases, however, which while well observed during life have been carefully examined after death by competent observers (Rothmann), showed no anatomical lesions whatsoever. The gut was entirely normal. These observations tally well with the results of the microscopical examination of the mucous discharges. The absence of all evidence of pus, the scanty occurrence of leucocytes, the absence of blood or of any constituents of the intestinal lining with the exception of epithelial cells, all point in the same direction. The multitude of epithelial cells that can be seen in every mucous discharge, and the fact that they are often present in extensive layers, do not of themselves speak for any anatomical lesion. It is well known that intestinal epithelium comes away very readily and yields to slight mechanical influences, and every normal stool contains great numbers of epithelial cells.

The facts that the majority of these cases occur in women, and that in nearly every instance neurotic or hysterical stigmata of various kinds can be established, speak also most emphatically for the merely functional character of this disease. It is therefore safe to assume that the so-called mucous colitis is no colitis at all, but, as was long ago suggested by Da Costa, and more recently clearly stated by Leube, a secretory neurosis, characterized by the abnormal and excessive secretion of mucus in the colon, and on a par with well-known secretory neuroses in other organs. It would be well, therefore, if the name colitis mucosa were abandoned altogether and, following the suggestion of Nothnagel, the disease termed mucous or membranous colic.

It must be borne in mind, however, that this neurosis, like any other, may complicate other organic lesions. Thus, besides the mucous colic, genuine intestinal catarrh may be present. And it is the duty of the physician in every instance to determine first of all whether he has to deal with a case of mucous colic, that is, a pure functional neurosis, or whether there are anatomical lesions—catarrh, ulceration, neoplasm, etc.—complicating the neurosis.

In considering the therapeutics of mucous colic it appears difficult or rather impossible to outline any special method of treatment. As in every other form of neurosis, each individual case must be studied and treated by itself. It is above all necessary to obtain the patients' confidence, to inspire them with the conviction that they can and will get well, and thus become assured of their implicit obedience in the carrying out of every order.

The habit which this class of neurotics invariably cultivate of anxiously scrutinizing each stool for mucus must be stopped. An inestimable advantage is gained if the patient no longer knows that mucus is discharged. Strict attention must be paid to diet. In all uncomplicated cases the diet should be as little restricted as possible and selected with a view to counteracting the habitual tendency to constipation, and increasing the weight and strength. Nothing encourages patients so much as when they find themselves enjoying their food and gaining weight. Exercise in the open air and rational hydrotherapeutics are valuable aids in the treatment of this form of neurosis as in all others. General massage may also be employed, but abdominal massage should be rigorously avoided. Local treatment of the gut by means of injections has been widely recommended. The astringent injections, especially of nitrate of silver, copious lavage of the bowel by means of high enemata or injections, etc., are still favorite methods of treatment in this malady. It is our conviction that all these methods are more harmful than curative. It is not wise in these cases to resort to any remedial measures which keep the patient's attention, already too much occupied with his ailment, still more centred upon his intestinal condition. Aside from this psychological objection, the fact is well established that astringent injections, be they never so mild, even enemata of plain water, or saline, have a direct tendency toward increasing the secretion of mucus. It is indeed possible by means of nitrate of silver to produce artificial casts of the gut. All local treatment, therefore, injections of all kinds, suppositories, etc., etc., should be strictly avoided.

When dietary measures alone are not sufficient to relieve constipation, mild aperients, such as cascara, castor oil, an occasional dose of calomel, etc., may be given. The salines in uncomplicated cases in which no intestinal catarrh is present do not, as a rule, act well. The attacks of pain and the tenesmus, when present, may be relieved by small doses of codeine or opium, though it must be borne in mind that this class of drugs should be employed most grudgingly. Besides the usual roborant and tonic medication (iron, strychnine, etc.) when indicated, good effect is frequently seen from nitrate of silver given by mouth in the form of enteric-, keratin-, or salol-coated pills in doses of gr. $\frac{1}{6}$ to $\frac{1}{4}$ three times a day. Sulphate of atropine in doses of gr. $\frac{1}{240}$ three times a day may also be of use.

Altogether the treatment must be mostly moral and hygienic, and, while all local interference with the intestines should absolutely be avoided, the use of drugs should be restricted as much as possible.

In conclusion it is well to state again that this method of treatment applies only to the uncomplicated cases of pure mucous colic. In all those cases in which there is organic lesion—be it catarrh, ulceration, or neoplasm—and in which the mucous discharge and the neurotic condition are merely complicating incidents, it is obvious that the whole force of treatment must be directed against the organic process. *Isaac Adler.*

COLLODION. See *Cotton, Gun.*

COLLOID.—This term is applied to many substances of different origin and nature, but which closely resemble each other physically, in that they are hyaline, colorless or slightly colored bodies of a gelatinous consistence. The colloid of the thyroid may be taken as the type to which the various bodies designated as colloid more or less conform. There is a great divergence of opinion among writers as to the use of the term colloid, some applying it not only to epithelial products but also to the hyaline changes occurring in connective tissue, to hyaline fibrin, blood-plate fibrin, keratin, keratohyalin, etc.; but it seems best to restrict the use of the word to those hyaline bodies formed by the activity of epithelial cells which do not give the staining reactions of mucin or pseudo-mucin. Even with this restriction in its use it is evident that the term is a collective one and that the substances included under it must differ widely in chemical nature. It seems advisable to the author to divide the substances known as colloid into two classes: true colloid, as found in the thyroid; and colloid-like bodies, the latter class including all the hyaline products of epithelial cell activity with the exception of mucin and pseudo-mucin. The corpora amylacea of the prostate, nervous system, and lung may also be included in this class.

In accordance with this classification, the terms colloid and colloid-like have reference only to general microscopical appearances and not to the ultimate chemical nature of the substance. They all, like mucin, are the products of epithelial-cell secretion, and may represent either normal or pathological forms of secretion.

True Colloid.—This occurs normally in the thyroid, where it appears in the form of hyaline, jelly-like masses of the color of honey, filling up the gland spaces and at times extending into the lymph vessels. Any collection of the substance beyond a certain degree is to be looked upon as a pathological degeneration of the glandular epithelium (colloid degeneration); and from this degeneration the condition known as colloid goitre results. Microscopically, the colloid of the thyroid is hyaline or slightly granular; it frequently contains blood cells, blood pigment, and desquamated epithelium showing varying stages of colloid change. Masses of calcification not infrequently occur in it. The substance is very resistant and is not affected by alcohol or acetic acid. With Van Gieson's stain it is stained yellow or brownish yellow; with eosin and hæmatoxylin it stains slightly with both the nuclear and the diffuse stain. The consistence of the thyroid colloid varies greatly; at times it is very firm, more often gelatinous, while occasionally it is fluid and soluble in water. It contains the active substance of the thyroid, iodothyrin, which is most probably an albuminous body. It is very probable that the chemical nature of the thyroid colloid is not always the same.

Colloid-like Substances.—These in general resemble the colloid of the thyroid, and are found in the hypophysis cerebri, parotid, renal tubules, prostate, ovarian and parovarian cysts, mammary gland, pancreas, etc. The corpora amylacea of the nervous system and lung are also to be included here. In all cases the colloid-like substance appears in the form of a smooth, homogeneous mass filling up the gland lumen or duct, or it may appear in the form of hyaline or laminated concretions. The colloid-like bodies of the kidney tubules are known as *casts*, and are of great clinical importance from their occurrence in the urine in pathological conditions of the kidneys (various forms of nephritis).

Though all of these bodies bear such a close general resemblance to each other, exhibiting similar reactions with ordinary stains, they cannot be identical in their chemical nature either with the true colloid of the thyroid or with each other. Some of them give a characteristic reaction with iodine, others do not, but this varies so much that it cannot be used as a means of classification. We are therefore compelled at the present to apply the term colloid to substances derived from gland cells, which are hyaline, possess a certain degree of firmness, and do not give the reaction for mucin or pseudo-mucin. Beyond this uncertain classification our terminology does not take us.

Aldred Scott Warthin.

COLLOID DEGENERATION OF THE SKIN.—This is a very rare affection of the skin, first described by Wagner as colloid milium. Hardly more than half a dozen cases of this rare disorder have been reported. It occurs chiefly upon the upper two-thirds of the face, especially upon the cheeks, forehead, and around the orbits; it has also been observed on the cornea and the septum nasi. The lesions form slowly—singly or in groups, never becoming confluent. They consist of pinhead- to millet-seed- or split-pea-sized, flattish, or irregularly rounded lemon-yellow colored papules, having a peculiar glistening, translucent appearance, that suggests their being vesicles, but when pricked only a small amount of a gelatinous substance accompanied by a droplet of blood can be expressed. Occasionally slightly dilated vessels surround the papules. Frequently a depression appears in the centre of the papule and increases in depth until the surrounding elevation disappears altogether; all that remains being a slight depression in the skin. Or, the part becoming inflamed, a scab forms over it and eventually drops off, leaving a mark, but no true cicatrix. The cause of the disease is unknown. It occurs in both men and women from the age of sixteen upward, no deviation from the normal health accompanying the disease to account for it. Most of the cases reported were in individuals living an out-of-door life much exposed to the weather.

Wagner at first thought that the cause began in the sebaceous glands, but this view has been practically discarded. Balzer considers that the colloid degeneration commences as an infiltration in and around the connective-tissue fibres and cells of the upper part of the corium. This change occurs especially in the neighborhood of the sebaceous glands and about the vessels and nerves. The glands themselves and all epithelial structures—except the endothelium of the vessels—escape. Baelzer could not determine the point clearly, but he thought it probable that the affection was due to primary vascular changes. The disease is not identical with hydradenoma, as Philippson endeavored to prove, though the differential diagnosis is often very difficult or even impossible without the aid of histological examination. From xanthoma, with which it most often is confounded, it may be distinguished by the glistening, translucent appearance of the lemon-yellow-colored elevations.

Treatment is unsatisfactory, no external application having any effect. Erosion with a sharp spoon has cured some cases, and electrolysis has been recommended and would seem best fitted to cope with the trouble without leaving very marked scars.

Charles Townshend Dade.

COLOCYNTH.—COLOCYNTHIN. "The fruit of *Citrullus Colocynthis* Schad. (fam. *Cucurbitaceæ*), deprived of its rind" (U. S. P.). The colocynth plant bears a general resemblance to the water and citron melons—near connections—but is smaller, slenderer, and besides rough-hairy, while the others are more nearly smooth. The fruit is globular, from two to four inches (10 to 20 cm.) in diameter, with a thin, leathery, mottled-green rind, and a fleshy, very bitter pulp. The latter consists of the mesocarp and three thick parietal placentæ which entirely fill the cavity and make a spuriously three- or six-celled, out of a normally one-celled, ovary.

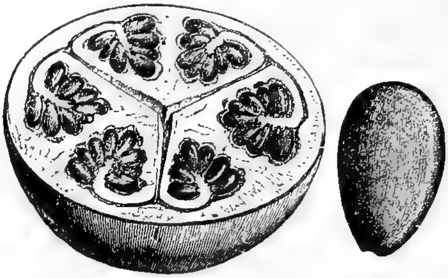

FIG. 1467.—Colocynth Fruit and Seed.

The plant is widely distributed over waste and desert places in India, Arabia, Syria, the "Levant," the Mediterranean islands, Northern and Western Africa, the Cape of Good Hope, Java, etc. In the Arabian desert, a resinous extract from the fruit is painted upon the water bags to protect them against attacks by the thirsty camels. It also grows in Spain and other portions of the extreme South of Europe, and has, in addition, been cultivated in several countries for many centuries. Cyprus, the South of Spain, and the African town Mogador, supply it for the market. It is collected when the fruit is ripe, or nearly so, and, in the European varieties, is usually peeled while fresh with a knife. The Mogador colocynth is oftener "coated," that is, dried without removing the exocarp. The soft, moist, greenish-white pulp shrivels considerably as it dries, and becomes nearly white, and very light and spongy. The composition and properties differ with the place of production. Some fruits grown in Texas were of prodigious size, but destitute of medicinal power.

DESCRIPTION.—As usually imported, colocynth comes in very light and brittle round balls, from one and a half to three inches in diameter (0.04 to 0.08 metre), composed of a nearly white, very fragile, cellular tissue; evidently cut over the surface with a knife, and containing numerous white or whitish cucumber-like seeds in six rows. These "balls" are easily broken into three parts, each including one of the placentæ, with a row of seeds on each of its two broken faces. The seeds, which, although of little bulk compared with the rest of the fruit, weigh heavily, contain seventeen per cent. of bland fixed oil, and have no medicinal value. They are thrown away when the pulp is prepared for use. This consists of exceedingly large and thin-walled parenchyma, enclosing about two per cent. of its weight of bitter extractive (colocynthin). The variety described above is Turkish colocynth. The Spanish variety is smaller, has a dark and much less spongy pulp and a larger number of heavier, black or blackish seeds. Not only is the percentage of pulp smaller, but it is also inferior. Colocynth pulp, freed from seeds, ground or whole, is an article of commerce. The presence of starch is an indication of adulteration, as this is wanting in the genuine article.

Composition.—The active constituents of colocynth are resin and *colocynthin.* The crystalline resinous body *colocynthitin* is not active. Gum and pectin are also present. Colocynthin ($C_{56}H_{87}O_{23}$?) is a yellow, powdery, bitter glucoside, soluble in both water and alcohol. It is purgative, but Merck claims that his is not poisonous or drastic like colocynth.

Colocynth itself is a harsh and irritating drastic, and seldom given alone. In small doses, and modified by other cathartics and corrigents, it is an excellent laxative, and in frequent use as a "dinner pill" in chronic constipation.

ADMINISTRATION.—There is but one immediate preparation, namely, the Extract of Colocynth (*Extractum Colocynthidis,* U. S. P.), made by evaporating a tincture. The yield is about sixty per cent. of the pulp. Dose, say 0.03 to 0.12 gm. (gr. ss.–ij.). It is seldom used alone, but enters into the Compound Extract of Colocynth (*Extractum Colocynthidis Compositum,* U. S. P.), which is in every-day use. Its formula is:

Extract of colocynth	16
Purified aloes	50
Cardamom	6
Resin of scammony	14
Soap	14
Alcohol	10

It is a fine powder, easily rolled into a pill itself, or mixed with still other substances. Dose, as a laxative, 2 or 3 dgm.; as a cathartic, five or six times as much (gr. v. ad xxv.). The Compound Cathartic Pills (*Pilulæ Catharticæ Compositæ,* U. S. P.) contain about one-third of their weight of this extract. Their composition is:

	Gm.
Compound extract of colocynth	80
Extract of jalap	30
Mild chloride of mercury	60
Gamboge	15

Mix and make one thousand pills. Dose, from one to three pills.

The compound extract is also an important ingredient of the official vegetable cathartic pills.

Pure colocynthin can be given in doses of gr. $\frac{1}{6}$ to $\frac{2}{3}$. A resinous extract is also in the market under the name colocynthin.

Merck recommends, as a purgative rectal injection, ♏ iv. to xvi. of a four-per-cent. solution of colocynthin in equal parts of glycerin and alcohol.

Henry H. Rusby.

COLON. (SURGICAL.)—The colon is wounded in the same manner as, though less frequently than, the small intestines. These wounds may occur from penetration of the abdomen by a knife, bullet, or blunt-pointed object, or rupture may occur from a contusion. Perforation from the effort to use the sigmoidoscope has also been reported. Wounds of the colon often occur in the separation of adhesions during intra-abdominal operations. The symptoms of a wound of the large intestine do not differ materially from those which present themselves when the small intestine is injured. Those wounds which are inflicted during operative procedures or in the course of an examination are readily observed. But accidental injuries can often only be surmised, the diagnosis of the part injured being determined only after an exploratory incision. While shock is to be expected in such wounds, it is frequently absent or present in only slight degree. Pain and tenderness are as a rule valuable symptoms, but their absence does not preclude the possibility of a wound. Paresis of the intestine and the resulting constipation usually occur early as the result of the violence producing the injury and later from the development of peritonitis. Vomiting is frequently an important symptom, especially as sepsis from extravasation develops. The presence of free gas in the peritoneal cavity is, if detected, a positive sign of rupture of the bowel. Tympanites over the area of normal liver dulness is a further evidence of this condition. Senn has advised the rectal insufflation of hydrogen gas to determine the presence or absence of an intestinal wound, especially in connection with perforating gunshot wound of the abdomen; the diagnosis is made when the hydrogen escapes from the wound. When this test is successfully made, it proves positively the presence of a wound, but failure of the gas to escape does not exclude injury. This procedure is not devoid of danger, for the increase of intra-intestinal pressure and the escape of the gas into the peritoneal cavity certainly favor fæcal extravasation and seriously interfere with any operative procedure which may be necessary. This, coupled with the fact that only in from three to five per cent. of perforating wounds of the abdomen do the viscera escape injury, makes it more advisable to perform an exploratory operation, especially as the latter increases the mortality very slightly, if at all, when done with proper aseptic precautions.

The records of wounds of the colon show a larger percentage of recoveries without operation than do similar injuries of the small gut, owing perhaps to the consistence of its contents and to less active peristalsis. These injuries are always serious and require prompt attention, as every hour of delay lessens the chance for recovery. Notwithstanding the number of reported recoveries without operation, the surgeon is certainly not justified in treating these cases expectantly. The method of dealing with intestinal wounds will be fully covered in another portion of this work. It is sufficient to state in this connection that the technique must be thorough and the closure perfect, sufficient lumen for the ready passage of fæces being allowed.

ULCERATION.—Ulceration of the colon assumes surgical importance when a tendency to perforation or to the development of stricture results. The causation and clinical history of many of these ulcerations are somewhat obscure. However, we meet with certain ulcers which present characteristics sufficiently distinct to be properly classified as dysenteric, typhoid, tuberculous, etc. The colon may be the seat of simple chronic ulcers similar in all respects to those seen in the stomach and duodenum. They occur very rarely, but are sometimes seen in patients suffering from Bright's disease. Vascular changes and emboli probably have much to do with their development. Sometimes a simple large ulcer is present, but as often several smaller ones are found. The edges of the ulcer are raised and slightly indurated, the base is somewhat regular. Healing may occur at one margin while the ulcerative process extends at the other. The ulcer may terminate by repair, and if, as is sometimes the case, it has extended around the intestine, narrowing may result. Perforation of the intestine is not infrequent and may be followed by fæcal abscess and fistula or peritonitis and death.[1] Parker reports two cases that terminated in fæcal abscess. Collections of fæces retained for a long time in the intestine excite an increased secretion of mucus, produce softening of the epithelium and necrosis of the mucous membrane, and result in the formation of one or more stercoral ulcers. These ulcers may excite a localized plastic peritonitis or they may perforate and cause acute general inflammation of the peritoneum. The shock itself may prove fatal. The sudden onset of pain and prostration in a case of prolonged constipation, especially with the presence of a doughy, irregular, and variable tumor, will point to perforation from stercoral ulcer. Ulceration at the seat of the solitary glands occurs in typhoid fever, and a few cases of perforation from such ulcers have been reported. These ulcers present the same changes which take place in the small intestine. Those ulcers which result from dysentery or which follow catarrhal colitis show little or no tendency to the formation of stricture. According to Woodward[2] no case of stenosis was reported as the result of chronic diarrhœa or dysentery among the United States troops from 1861 to 1865, although a vast number of soldiers suffered from these diseases. Syphilitic ulcerations of the large intestine are usually limited to the rectum. They result from the breaking down of gummatous deposits in the submucous tissue. Malignant disease produces ulceration, and stenosis results from cicatricial contraction as well as from the encroachment of the neoplasm. Tuberculous ulceration occurs with great frequency. About one-half of the cases of tuberculosis show lesions in the intestine. The lung is the only organ more often attacked. These lesions are situated most often at the lower part of the ileum and in the beginning of the colon. They may be primary, or secondary to a focus situated elsewhere. In children primary involvement is the rule and the intestinal lesion may be so slight as to escape notice, while the mesenteric glands will be greatly involved. In adults the lesions are more often secondary, and the solitary glands of the cæcum are often involved and show the characteristic deposit of tubercle. This deposit undergoes softening and the cheesy material is emptied into the intestine. An ulcer results which tends to spread around the circumference of the intestine, in the course of the vessels, as well as deeply through the wall. The peritoneum over the ulcer often shows yellowish, opaque tubercles in its structure, the surrounding tissues become adherent, and contraction of the inflammatory product may cause constriction of the intestine. The girdling ulcers tend in their repair to produce stenosis and frequently excite symptoms of obstruction. Perforation of the intestine is by no means infrequent and may give rise to fæcal abscess and subsequent fistula or may excite general peritonitis as in simple ulcer. Ulceration of the colon presents few characteristic symptoms; there may, in fact, be nothing to indicate the condition even when marked and extensive lesions are present. Diarrhœa more or less persistent, with periodical constipation, is usually present. Mucus, shreds of tissue, some blood and pus may at times be found in the discharges. In tuberculous ulceration, the patient will lose in flesh and strength and will complain of pain, especially in the lower part of the abdomen. This pain is increased upon slight exertion. Localized tenderness on pressure without rigidity may be noted in these cases, and, as in other tuberculous processes, a slight evening elevation of temperature may be observed. As stricture develops, after the symptoms named above have lasted for months, constipation becomes more and more marked until the stools are completely arrested. In rare cases this condition may occur suddenly and may present the usual symptoms of intestinal obstruction, as nausea, vomiting, pain, distention, and obstinate constipation. Perforation will be known by the shock, distention, pain, tympanites, etc.

Diagnosis.—The diagnosis is at all times difficult, and it is extremely probable that cases of ulceration will be determined only after stenosis occurs, or after exploration.

Treatment.—This is operative, and colectomy should be performed for tuberculous and malignant ulceration when extirpation can thus be effected. The operation is also indicated in other forms of ulceration where perforation is imminent and the process is not too extensive. Tuberculous and malignant cases in which the disease cannot be extripated are best treated by anastomosis. Extensive ulcerative colitis has been successfully treated by colostomy and flushing the colon from the artificial opening to the anus. Mayo Robson,[3] Golding Bird,[4] and others have reported cases of recovery after this plan of treatment.

Stenosis.—Non-malignant stenosis may follow almost any form of ulceration, but the most frequent process is one of a tuberculous nature. The constriction may take place a long time after the ulceration. Owing to this fact strictures are noted more frequently in adults than in children. Many cases of stenosis are unrecognized during the life of the patient. Two or more points of stricture may be present in the same case. No portion of the colon is exempt from this lesion.

Symptoms.—The chief symptom of stenosis is constipation, which may gradually become more and more persistent or may occur suddenly and become complete. If relieved temporarily, a return of the constipation is to be expected in a short time. The patient will perhaps give a history of troublesome diarrhœa, the passage of some mucus and blood having occurred at some previous time. Obstructive symptoms sooner or later set in, and, while not so marked as in some other forms of obstruction, are very persistent. Uneasiness in the abdomen soon becomes pain which is paroxysmal and is increased by purgatives. The abdomen may become distended, but as a rule it is flaccid unless peritonitis is present. After a time vomiting begins, first of gastric contents, later of fæces unless the obstruction is relieved. The patient loses flesh and strength and, after some days of suffering, death follows from sepsis and exhaustion.

Diagnosis.—The symptoms of recurring and more or less obstinate constipation, when associated with emaciation and in the absence of stenosis of the rectum, will usually mean stricture of the colon. Obstruction of the small intestine will usually present a more acute train of symptoms. In stenosis of the colon vomiting is not so prominent a symptom and becomes fæcal at a much later date than it does in occlusion of the small gut. The absence of a neoplasm will exclude malignant stenosis.

Treatment.—Avoidance of purgatives will save the patient much discomfort. Copious enemata will give relief during the early stages. When obstruction occurs or attacks of constipation are often repeated, operation is indicated.

Fæcal Fistula.—Sinuses leading from the colon to the surface and discharging fæces and gas result from wounds which have not been treated or which have been improperly closed; from contusions without immediate rupture but followed by sloughing; and, finally, from slipping of the ligature or sloughing of the stump after operative interference for the relief of appendicitis. The pressure of a drainage tube is not infrequently a cause of this condition. The same is true of gauze drainage, the removal of which sometimes produces a tear of the intestine. Tuberculosis of the colon may cause perforation and thus lead to the formation of fæcal fistula. In dealing with strangulated hernia associated with gangrene of the gut, the surgeon may deem it best, if the patient's condition precludes the completion of colectomy, to temporize by the establishment of a fæcal fistula to be cured by a subsequent operation (colotomy). In malignant disease the formation of a permanent fistula (artificial anus, colostomy) has become a recognized surgical procedure.

Pathology.—When from any cause the continuity of the intestinal wall is disturbed, gas and fæces in a short time escape, and under the most favorable conditions excite a localized plastic inflammation in the surrounding peritoneal surfaces, with the tendency to the formation of adhesions and isolation of the focus of irritation. In time the surface is reached through an abscess—where the abdominal wall is intact—or through the wound if one exists, and the fæces then escape externally. When a wound of the abdomen is present, the communication is usually established within a week after the injury. When the abdominal wall is intact, a longer time will elapse before the fistula develops. The general peritoneum is protected by a fibrinous lymph, and the fistula is lined with granulation tissue. When the damage to the colon is slight and when surrounding parts lie in close relation to the wound of the gut, the tract will gradually contract and eventually heal. This is the most frequent termination of such cases. A fistula may persist when the intestine is fixed directly to the skin without intervening sinus, when the wound in the bowel is very large, or when more than one opening exists; also when there is obstruction to the passage of fæces through the bowel below the fistula, owing to a stricture, tumor, or bend of the intestine. Tuberculous fistulæ are very persistent, and repair will be unlikely when an abscess cavity is formed in close proximity to the intestinal opening, due perhaps to a failure of the walls of the abscess to collapse. The symptoms indicating the development of fæcal fistula are the presence of a peculiar dark, blackish, brown stain upon the dressings and the detection of a distinct and persistent fæcal odor. A mistake is scarcely possible. Some difficulty may be experienced in determining the location of the intestinal opening, but this will prove of little moment. In some instances progressive emaciation accompanies the condition, but usually the patient is well nourished. The prognosis of this condition is as a rule good, and special attention will be demanded only after it persists for some months. The affection is always disagreeable, but its seriousness is certainly less than in the case of a fistula leading to the small intestine.

Treatment.—Upon first impulse it would appear reasonable to insert drainage in some form to remove the fæces and to keep the skin wound patulous. Considerable experience in such cases teaches us that such a procedure is unnecessary and frequently productive of harm, owing to the fact that no drain will carry off the fæces as well as the pressure within the intestine. Moreover, when the fæcal matter remains pent up in the tract, symptoms of sepsis shortly appear. The condition is best treated by placing over the external opening a large loose pad of sterilized absorbent material, and retaining it in place by a bandage. These dressings should be changed whenever they become soiled; sometimes this is necessary as often as four or five times a day. When the dressings are changed, gentle pressure near the fistula will force out the contents and cleanse the tract. The skin should be washed with cold water and alcohol, and when any excoriation occurs the parts should be anointed with vaseline at each dressing. The bowel below the fistula should be kept patulous by enemata to make the passage easier in that direction than through the abnormal tract. Laxatives should be used only to prevent constipation and too great solidity of excreta.

The patient's health should be kept up by tonics and nutritious, easily digestible food. If, after several months of this treatment, the fistula persists or if emaciation is rapid, an operation for the cure of the affection should be undertaken. This operation is often very difficult, but, with proper care to protect the general peritoneum, it can usually be safely accomplished. Cleansing of the field of operation must be absolute. The tract should be well scraped and thoroughly flushed with 1 to 1,000 bichloride solution. In curetting the fistula care must be exercised to avoid injury of an adjacent fold of intestine. The application of pure carbolic acid to the tract is advisable, and this should immediately be followed by the application of about eighty-per-cent. alcohol to prevent too extensive action. In order that the canal may easily be traced it should be packed with gauze. The incision should be made with the greatest care to avoid injury of the bowel, which is almost always adherent to the abdominal wall around the fistula. Therefore begin the cut some distance away from the fistula, and after the peritoneum is opened, with the finger inside the abdomen, separate the adhesions until the incision can be safely continued. Protect the general peritoneum with flat gauze sponges. When the tract is short the intestine can be readily loosened, lifted into the wound, and sutured or resected. When the bowel lies six or eight inches from the outlet of the fistula, considerable dissection will be necessary to free the adhesions and this requires the greatest care. The edges of intestinal openings are pared if necessary and coapted by Lembert sutures of fine silk. Usually a second supplementary series of sutures will be necessary. When the intestinal wound is so large that the lumen of the gut will be constricted, a colectomy will be necessary. The toilet of the peritoneum must be made in the most thorough fashion, and after the tract of the fistula in the abdominal wall has been excised, the wound may be closed completely—provided the operator is convinced that the peritoneum has not been soiled—or it may be left sufficiently open to provide the necessary drainage outlet. The old method of closing an artificial anus by the pressure of a clamp, as advised by Dupuytren in 1815, certainly has no advantages over the operation just described and is not to be recommended.

INTUSSUSCEPTION; INVAGINATION.—The abnormal reception of a portion of the intestine within an adjoining and continuous segment constitutes an intussusception. This condition may develop in any part of the canal, but is most likely to occur at the ileo-cæcal valve. It forms about forty per cent. of all fatal cases of intestinal obstruction. According to Treves, five per cent. of such cases occur under two years of age. At the point of invagination three thicknesses of the intestinal wall lie in close proximity to each other. The outside fold is known as the receiving layer or intussuscipiens, the internal as the entering layer, and the middle is called the returning layer. The last two are also known as the intussusceptum. The peritoneal coverings of the entering (internal) and the returning (middle) layers lie in contact and in a short time become firmly united, while the mucous surfaces of the receiving and returning folds show no such tendency.

The descent of the gut exerts traction upon the mesentery and compression of its vessels at the point of invagination, thus producing venous obstruction with swelling and œdema of the intussusceptum. Softening and gangrene may produce perforation, or bacteria may multiply rapidly in the congested wall and excite a rapidly fatal form of peritonitis. In rare cases nature effects a cure through sloughing of the invaginated segment, after adhesions have formed, at the line of entrance, sufficiently strong to prevent rupture. Usually intussusception is acute and rapidly fatal, but in adults one may encounter the chronic form which after two or three weeks of suffering may terminate in recovery, or which may prove fatal through chronic diarrhœa, septic emboli, perforation, peritonitis, etc. As a rule, in children it is quickly fatal. Its causation is not well understood. Spasmodic peristalsis, which forces the contracted portion into a relaxed segment, or a paralyzed segment into a normal one, has been advanced to account for its development. The experiments of Nothnagel seem to show that contraction of the longitudinal muscular fibres will draw a relaxed portion over a contracted one. The presence of polypi is supposed to favor the development of invagination. The anatomical relation of the ileum to the cæcum must also be considered as a predisposing factor.

Symptoms.—The attack begins suddenly with severe griping and colicky pains, accompanied by marked anxiety and shock. Vomiting is usually present, as is constipation after the bowel below the obstruction is emptied of its contents. Some mucus and blood may pass and the tenesmus is marked. Upon examination a sausage-like abdominal tumor can often be detected, especially when the end of the ileum has entered the colon.

The *Diagnosis* is based upon the sudden onset, peculiar pain, sausage-shaped tumor, and the passage of blood-stained mucus without fæces. At times the exact cause of the obstruction will be determined only after the abdomen is opened. The prognosis, as incidentally mentioned before, is always grave, and in most cases a fatal termination occurs in less than one week.

Treatment.—Avoid purgatives, and during the first twenty-four hours endeavor to set free the invaginated segment by distention of the colon with gas, air, or water while the patient is in the knee-chest position. Belladonna and opium may be cautiously administered to allay spasm and limit peristalsis. Do not give enough opium to mask the symptoms. If this treatment fails to relieve, a laparotomy should be performed—preferably the median operation, unless a well-defined tumor is present, in which case the incision should be made directly over the swelling. Stimulants will frequently be needed to counteract shock.

Technique.—Under the strictest asepsis the abdomen is opened and search made for the seat of obstruction, first in the right iliac fossa and with as little exposure of the intestines as is practicable. A needless exposure of the intestines will greatly increase shock and lessen the chances of recovery. The mass should be brought into the wound and protected by hot pads of gauze, while gentle efforts are made to relieve the invagination. If continuity is restored without damage to the bowel, recurrence can be prevented by suturing the mesentery to the abdominal wall. If reduction is impossible, if malignant disease is present, or if the intestine is gangrenous, colectomy should at once be performed, and resort to colostomy should be had only when the patient's condition prevents the operator from making the complete operation. The wall of the abdomen is to be closed as in other cases of abdominal section.

VOLVULUS.—Volvulus constitutes one of the most fatal forms of intestinal obstruction. The term is applied to a twisting of a segment of the intestine and its mesentery so that the circulation of the blood and also the passage of fæces are interrupted. Such a twist can occur only in cases in which the peritoneal attachment is sufficiently long to allow considerable mobility of the gut. The sigmoid flexure, therefore, is the part of the colon which is most subject to this accident. Sudden distention of the intestine with gas, or the presence of a fæcal mass, with or without an accompanying strain, may cause volvulus. When the torsion occurs, swelling of the twisted portion follows immediately, owing to interference with the return of venous blood. This swelling tends to accentuate the twist and to increase the obstruction to the blood supply. The adjacent portions of the intestine are distended with gas, which tends to prevent spontaneous restoration. Gangrene follows in a short time, and peritonitis is present if the patient lives long enough for its development. The prognosis is essentially grave. Spontaneous restoration rarely, if ever, occurs and no measures save operation offer any hope to the patient.

Symptoms.—The patient is suddenly seized with vomiting, which is not so severe in volvulus of the colon as it is in volvulus of the ileum. Severe paroxysmal pain radiating over the abdomen, with extreme tenderness, is always present. Sudden cessation of pain announces the development of gangrene. Pain returns with the development of peritonitis. Obstruction is complete. Early and circumscribed tympanites may precede general distention and rigidity. Rectal examination may reveal a mass in the pelvis in case a twist lies in that region. Marked restlessness and prostration are always present and the patient shows great anxiety. The surface shortly becomes cold and clammy and covered with perspiration. Hiccough soon appears and the circulatory and muscular systems become rapidly depressed.

Diagnosis.—Sudden onset of obstinate constipation (bowels regular before), vomiting, pain, tenderness, and localized tympanites without a tumor or a hernia will point strongly to volvulus. It is not always possible to make out the exact seat of the obstruction, but the symptoms described will call for exploration.

Treatment.—Palliative measures, purgatives, rectal injections, etc., are worse than useless. An early laparotomy offers the only hope for the sufferer. When this is performed early the result is very gratifying, but delay is dangerous. The mesentery should be sutured to the abdominal wall to prevent recurrence. When the bowel is gangrenous (which is shown by its dark color and the ease with which the peritoneum is separated from the muscularis), immediate resection with end-to-end or lateral anastomosis, or the formation of a fæcal fistula, is the proper surgical procedure to be adopted in a case of this nature.

IMPACTION.—Fæcal impactions are more likely to occur in the colon than in the small intestine, but less frequently perhaps than in the rectum. The right and left iliac fossæ are the most frequent sites. This condition develops in patients who have a tendency to constipation, and the accumulation occurs more or less slowly with intermittent attacks of diarrhœa until ulceration or complete obstruction occurs.

Symptoms.—Sometimes the first symptoms are diarrhœa with tenesmus, night sweats, loss of appetite, flesh, and strength, following a more or less constipated condition. In time constipation will take the place of the diarrhœa and there will be evidence of obstruction associated with pain, slight tenderness, and distention. Examination will reveal a tumor which is doughy to the feel, which can be indented, and which varies in size and shape.

Treatment.—Large enemata of salines, oil, soapsuds, etc., in Hegar's knee-chest position, with gentle kneading of the abdomen, will usually afford relief. If these means fail, the surgeon should resort to a laparotomy, which will render it possible to break up the mass by gentle manipulation of the intestine. Recurrence can be prevented by the administration of such remedies as belladonna, nux vomica, aloes, and cascara sagrada to tone up the intestine. Daily massage of the abdomen and proper diet are of marked benefit. When the mass is very large and danger of rupture of an ulcerated colon is present, a colotomy is justifiable.

TUMORS.—Benign tumors rarely develop in the colon. Papillomata, adenomata, and fibromata sometimes form pedunculated tumors that project into the intestine and thus may give rise to intussusception by exciting efforts of expulsion. They may also grow to sufficient size to produce obstruction. As a rule these growths are single, but occasionally they are multiple. Lipomata sometimes appear as pedunculated growths upon the peritoneal surface of the intestine, where they have as a rule little pathological importance. These tumors also develop in the submucous tissue, extend into the intestine, and may even completely occlude the canal. Hofmokl[5] reports a case of this kind in which the tumor obstructed the lumen of the intestine for a distance of several inches and caused invagination of the colon. Annular benign growths are sometimes seen springing from the middle coat of the intestine; these are, as a rule, fibromyomata. Benign growths only demand attention when they cause intussusception or obstruction. Sarcoma attacks the colon very rarely indeed, even less frequently than it does the small intestine. Sarcomatous growths springing from adjacent organs may involve the colon and in the course of their growth produce obstruction. Clinically it is impossible to differentiate between sarcoma and carcinoma of this structure. Sarcoma possesses no tendency to spread through the lymphatics and may be expected to occur earlier in life than carcinoma. The final results are very similar in either instance. Owing to the amount of involvement which takes place before these tumors are recognized, removal rarely proves of benefit and an early recurrence is to be expected. Therefore enterocolostomy, or as it is sometimes called, short-circuiting of the intestine, will be the operation that offers the most to these patients. By this procedure the irritation of the fæces and the tendency to obstruction can be relieved. Senn has proven that a segment of intestine isolated in this way is able to rid itself of its secretions and of fæces which may enter it accidentally.

CARCINOMA.—The large intestine is somewhat frequently attacked by this variety of neoplasm; about seven per cent. of all cancers have their origin in this organ. According to Sutton, ninety-eight out of every one hundred intestinal cancers have their origin in the large bowel and about seventy-five of these involve the rectum, ten the sigmoid flexure, and fifteen the cæcum and remainder of the colon. According to Leube, four-fifths of all cancers of the large intestine occur in the rectum and one-fifth in the colon and sigmoid. These growths spring from the mucous surface and from the glands of that structure and infiltrate, as they grow, into the deeper tissues of the intestinal wall. The histological structure resembles more or less closely that of the benign adenomata, yet this variety of new growth shows a great tendency to infiltrate surrounding tissue. These tumors may project into the lumen of the intestine or spread through the submucous tissue until the entire circumference of the bowel is involved. In time ulceration occurs, and with it the contraction of the newly formed tissue until the canal is partially or completely occluded. Secondary involvement of the intestine by extension from carcinomata of neighboring organs not infrequently occurs, and as a rule such cases are inoperable owing to the wide dissemination of the disease. Cancer of the large intestine may exist for some time without giving rise to any distinct symptoms indicative of its presence. During this time some irregularity of the bowels may be present, but as a rule not of sufficient moment to demand attention. After a time there may be noted a sense of uneasiness or discomfort in the abdomen, and this is soon followed by more or less constant pain and tenderness. This pain is at times colicky in character. Loss of flesh and strength greatly out of proportion to the discomfort of the patient accompanies the foregoing symptoms. The appetite and digestion are at first unimpaired, but cachexia soon develops. When ulceration begins blood-stained mucus, shreds of broken-down tissue, and some pus are passed with the fæces. As the ulceration progresses diarrhœa and pain become constant and severe, and the slight septic intoxication which results causes loss of appetite and anæmia. Constipation becomes more and more marked until complete obstruction develops as the result of stricture. Intestinal obstruction may be the first symptom to appear. Ulceration often occurs above the stricture, and a number of fistulæ may form between the two portions of the intestine or between the proximal portion and the surface. The surrounding parts become involved finally and a peritonitis with ascites develops. Examination at this time will reveal the presence of a nodular tumor unless it is masked by the ascites. The positive *diagnosis* of carcinoma of that portion of the intestine which is beyond reach of the finger and rectal examination can usually be made only by an exploratory incision through the abdominal wall. Rapid emaciation and the history of irregularity of the bowels, uneasiness and pain in the abdomen, with a gradually increasing costiveness, will point strongly to cancer of the intestine.

Prognosis.—This is, as a rule, a fatal affection. The only chance offered for the patient is by an early and complete extirpation of the disease. In cases in which this is impossible and in which symptoms of obstruction or marked ulceration are present, either colostomy or lateral anastomosis will give temporary relief and perhaps extend the life of the patient. Colostomy is to be performed when the growth is in the lower portion of the intestine. Lateral anastomosis is indicated when the growth is situated high in the colon and extirpation is not feasible.

OPERATIONS UPON THE COLON.

Colotomy.—This term has for centuries been used to designate the formation of an artificial anus, but recent writers have limited its meaning to incision of the colon for the purpose of making a temporary opening; while the term colostomy is applied to the establishment, by operative measures, of a permanent opening into the colon. Therefore we shall in this connection make a distinction in accordance with the literal meaning of the terms. Colotomy is indicated for the removal of foreign bodies lodged in this part of the intestine, for the relief of fæcal impactions which cannot be otherwise removed, for the establishment of a temporary opening in a case of imperforate anus, or in one of ulceration of the rectum or lower part of the colon. The incision should be made over the swelling in the first two instances, or in the median line if the diagnosis is not made. When the operation is made for imperforate anus, the left inguinal region is best, as it also is for colostomy. When the intestine, which may be recognized by the longitudinal bands and fatty appendages, has been pulled into the wound, the diagnosis should be confirmed before proceeding with the operation. The peritoneum should be protected with gauze and an incision made longitudinally through the wall of the intestine. The foreign body or fæcal concretion should then be extracted and the part thoroughly flushed with saline solution. Closure of the intestinal wound is then accomplished by interrupted Lembert sutures of fine silk or of strong catgut. The needle should penetrate the submucosa which holds the stitch in place. It will usually be advisable to supplement with a second row of sutures. When one is satisfied that approximation is perfect, the colon should again be flushed and dropped into the abdominal cavity. The abdominal wall is closed in the usual manner without drainage. When the operation is performed for imperforate anus and for painful ulceration and inflammation of the rectum, the intestine should be brought only partially out of the wound and fixed with angulation so that excision will not be necessary when a cure of the fistula is indicated.

Artificial Anus or Colostomy is the operation of forming a more or less permanent opening from the colon to the surface. The indications for colostomy are:

1. Obstruction of the intestine below. (*a*) From inoperable tumor; (*b*) from stricture of the rectum or colon.
2. Congenital malformation of the rectum and anus.
3. To relieve the pain and irritation of intractable ulceration of the rectum, either simple, syphilitic, tuberculous, or cancerous, and to prevent the fæces passing over the diseased area.
4. To relieve incurable recto-vesical fistula.

Iliac Colostomy was first proposed by Littré in 1710 and frequently is known as Littré's operation, although it was not performed until 1776 by Pillore. It was employed at intervals after this time, but with a mortalityso high that it was abandoned in favor of lumbar colostomy, proposed by Callisen in 1796 and successfully performed by Amussat in 1839. According to the statistics of Dr. Batt, the mortality of the lumbar method was 31 per cent. and of the iliac 53 per cent. Mr. Cripps performed 14 lumbar and 27 inguinal colostomies with one death. With the perfection of surgical technique, the objections to the inguinal method have disappeared, so that at the present time lumbar colostomy is rarely performed. Inguinal colostomy places the artificial anus in a position where the patient can properly care for it with ease. The colon is more readily accessible by this route than through the loin, and the operation is equally safe. The fæcal flow can scarcely be entirely cut off from the lower part of the intestine in the lumbar operation, thus failing to meet an important indication, and when a long meso-colon is present the lumbar route is useless. Objections have been urged to the establishment of a fæcal fistula in any case, but patients can pass a very comfortable existence for a number of years after its formation. Those patients are most comfortable who have means and leisure to take care of themselves, but even the working class can follow their usual vocations with comparative comfort. Some operators recommend excision of the rectum, as the operation of choice, but the majority of the profession prefer colostomy. When the obstruction lies higher in the colon, the opening can be made in the transverse portion or in the cæcum, but the usual site is in the left iliac fossa. An incision about three inches in length should be made parallel to Poupart's ligament and about one inch and a half internal to the anterior superior spine of the ilium. This incision at its middle should cross an imaginary line drawn from the anterior superior spine to the umbilicus. If each layer of muscular fibres is separated by blunt dissection and the retractor used to keep the wound open, considerable control over the orifice can be obtained for the patient after repair has occurred. The finger introduced into the wound and carried deeply outward toward the anterior spine will catch and bring the colon into the wound where it can readily be recognized. The intestine should be pulled down until the meso-colon is on the stretch to prevent prolapse through the artificial opening. The whole thickness of the gut should be brought out of the wound to make a strong flexure, and it should be held there by a glass rod, through the meso-colon as advised by Maydl, or by a silkworm-gut suture as advised by Kelsey.

The skin, the peritoneum of the parietes, and the wall of the intestine should be united by eight or ten sutures of catgut or silk, thus closing the peritoneal cavity from chance of infection when the intestine is opened. Before these sutures are inserted, one or two silkworm-gut stitches should be passed through skin, muscles, and fascia at the upper and lower angles of the incision to bring the tissues snugly about the bowel. The wound can be hermetically sealed by a thin layer of sterilized cotton and collodion, leaving the intestine exposed for immediate opening if desired. When the wall of the intestine is pared away some hemorrhage may require attention. In cases in which the symptoms of obstruction are not urgent it is quite proper to wait three or four days before incising the intestine, as the mortality heretofore has been greatly decreased by such delay. General anæsthesia is usually unnecessary for opening the intestine after such postponement.

Lumbar Colostomy.—This, often known as Amussat's operation, can be more readily performed if the colon is distended as in stricture with obstruction. Under anæsthesia the patient should be placed on his right side upon a firm pillow to arch the left loin as much as possible. A perpendicular line drawn from the middle of the crest of the ilium, or, according to Allingham, from a point a half-inch behind the middle, will mark the situation of the colon. An incision four inches long should be made parallel to the last rib and half-way between it and the crest of the ilium with its centre in the line just mentioned. The muscular tissue and fascia for the whole length of the wound must be carefully divided until the transversalis fascia and the edge of the quadratus lumborum are exposed. When this fascia is cut through, the colon will present itself. Unless it is collapsed it can easily be recognized by its color, by the thickness of its walls, and by the scybalous masses which it usually contains. Care should be exercised to avoid opening the peritoneum. The colon should be drawn into the wound and sutured to each margin. The wound should be closed with silk-worm gut, an opening being left at one point for drainage; and when obstructive symptoms are not urgent several days may elapse before the intestine is opened.

Colectomy.—Excision of part of the colon has been performed with considerable frequency during the past ten years. The ileo-cæcal coil appears from the reported cases to be the part most often removed (ileo-colectomy). Magill in 1894[6] collected one hundred and four cases of resection of this portion of the bowel, with a mortality of thirty per cent. The first resection of the ileo-cæcal fold was performed by Krausshold, 1879, with a fatal result. Maydl, in 1882, operated successfully. Since that time the operation has become a recognized surgical procedure. The following conditions may demand resection of the colon: 1, malignant disease (carcinoma and sarcoma); 2, tuberculosis; 3, invagination, acute and chronic; 4, fæcal fistula; 5, gangrene from volvulus or bands; 6, gangrene from hernia; 7, wounds with considerable loss of substance; 8, inflammatory strictures; 9, irreducible cæcum in hernia.[7]

The feasibility of resection can be determined only after exploration and inspection of the diseased intestine. The most frequent indication for the operation will be a removable malignant growth; the other conditions mentioned are also frequently best treated by colectomy. The larger number of fatalities appear to be due to faulty technique, and improvement along this line will materially lessen the death rate. The mortality differs materially in the different conditions that call for the operation, being 16.6 per cent. in tuberculous disease and as high as 40 per cent. in invagination. Cancerous cases show a mortality of 33⅓ per cent. This appears to show that the peritoneum will prove more resistant to infection in tuberculous cases than in any others, and can then be handled with a greater degree of safety.

The preparation of the patient should be the same as that carried out for any abdominal operation and should receive the most careful attention. In cases of obstruction purgatives cannot be used, but in other instances the canal should be thoroughly emptied of its contents. The line of incision will depend upon the part of the colon involved. Any portion can be reached by a median incision, but the operations upon the cæcum or sigmoid flexure will prove very difficult through such an incision. One case is recorded in which an incision from the ensiform to the pubes was found necessary in order to complete the operation. For the two regions mentioned an incision in the respective iliac region four inches long, parallel with and about one inch and a half internal to Poupart's ligament, with its centre on a leval with the iliac spine, will prove satisfactory. This can be extended directly upward if desired after digital exploration of the region. All bleeding from the wound should be arrested before the peritoneum is opened. The diseased portion of the intestine should be well isolated by gauze pads to prevent contamination of the peritoneal cavity. The mesentery of the segment to be removed should be tied off in sections or clamped and ligatured after the bowel is removed. The first is perhaps the better method. These ligatures should be of strong catgut and the included mesentery should not extend beyond the point at which the intestine is to be divided. The bowel above and below the portion to be removed is emptied as nearly as possible of its contents and held firmly closed by the fingers of an assistant, by rubber-covered clamps, or by gauze tapes. In competent hands the first plan is the best, as there is less danger from pressure exerted in this manner. The intestine is then divided by sharp scissors and dissected carefully away from the surrounding parts. Watch must be kept for the ureter, which may be wounded in resection of either end of the colon. The continuity of the intestine can then be restored (1) by end-to-end sutures, (2) by lateral anastomosis accomplished by means of absorbable plates, (3) by lateral or end-to-end anastomosis with the aid of Murphy's buttons, (4) by lateral implantation in ileo-colectomy, or (5) by lateral anastomosis with the aid of clamps of H. H. Grant or La Place. In cases in which the patient's condition will not permit the completion of any of these steps a fæcal fistula can be formed. It should be remembered, however, that this entails the danger of a later operation and therefore should be avoided if possible. The end-to-end suture may be accomplished by the method of Czerny-Lembert (modified by Woelffler), which calls for two rows of sutures, the first penetrating the mucous and muscular coats, but not the serous. Avoid infection of the peritoneum, which is inverted by the second row of sutures inserted after the method of Lembert. The following method is more often employed: The cut ends of the intestine are held together by an assistant while four or six interrupted Lembert sutures are inserted at intervals around the bowel to approximate the segments. These sutures should invert less than one-eighth of an inch of the open wall of the intestine, thus bringing the serous surfaces into apposition. Another row of Lembert sutures, interrupted or continued, should be applied over the approximation sutures to render the closure efficient. The greatest difficulty in preventing leakage will be experienced at the mesenteric border; therefore especial care must be given to suturing at that point. Too great inversion of the cut edges may produce

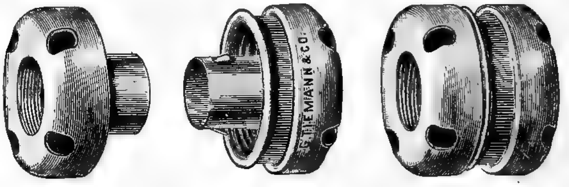

FIG. 1468.—Murphy's Buttons.

obstruction when repair is accomplished. The operator should be perfectly sure that the walls of the intestine are impervious and that its lumen has been restored before he completes the other steps of the operation. This can be determined by forcing the contents from above through the point of anastomosis, while the intestine is occluded below by pressure of the hand. The exposed parts should be thoroughly flushed, the redundant mesentery folded and sutured in such a manner that it cannot possibly produce strangulation, and the intestine dropped into the abdomen. When the suturing is perfect there need be no fear of extravasation, and gauze wicks are therefore unnecessary and often productive of harm. The omentum is drawn down in front of the intestines and the abdomen closed without any provision being made for drainage. It has been claimed that anastomosis by suturing, either end-to-end or laterally, requires considerably more time than when absorbable plates or buttons are employed, that leakage is more likely, and therefore that it is not as useful as one of the latter methods. The same amount of preparation for this operation in the dead-house or upon animals will make an operator about equally expert in the use of either plan. Leakage is no more likely from direct suturing than when some appliance is used, and perhaps less so, owing to the sloughing which sometimes follows the use of either the button or the absorbable plate. The Murphy button will undoubtedly prove the most rapid method for anastomosis, and in the colon will cause little inconvenience from its presence as a foreign body. The different forms of clamps proposed for anastomosis require more skill in manipulation than the other methods, save nothing in time, and will scarcely be generally adopted. The Murphy button is the best of the mechanical aids to intestinal suturing, and is equally suitable for end-to-end or lateral anastomosis. One section of the button is held in the open intestine by a running stitch, known as a purse-string suture, which is pulled tightly around the button as it is tied. The sections of the button are then pushed together and locked. A few stitches can be inserted to reinforce the line of coaptation. The mesentery should be cared for as in the direct suture and the operation completed in the same way.

Lateral Anastomosis by Plates.—The open ends of the intestine should be closed by two layers of fine silk sutures passing deeply enough to catch the submucosa, then an incision is made in each bowel opposite its mesentery about one inch and a half from the closed end and long enough to admit the narrow diameter of the absorbable plate. The plates proposed by Senn are made of compact tissue of a large beef bone which has been decalcified by immersion in ten-per-cent. solution of hydrochloric acid. Oval plates, 7 cm. long, 3 cm. wide, and 5 mm. thick, are then cut out of the bone. An elliptical opening is made in the centre of the plate 3 cm. long and 7.5 mm. wide. At each end and at the middle of each side a hole is punched in the bone near the margin of the opening. Through these holes double threads are carried, leaving a needle at each lateral hole and a knotted thread at each end. When the plates are placed longitudinally in the intestine the needles penetrate its wall and the corresponding threads are tied snugly to those of the opposite plate. In this way the two intestines are approximated. A continuous Lembert suture completes the anastomosis. The only objection to this method is the danger of infection through the stitch wounds in the intestinal wall. Von Baracz' vegetable plates are cut of the same size and shape as Senn's bone plates and the operation is performed in the same manner. Many other mechanical appliances have been proposed, but the ones mentioned are the best.

Lateral Implantation is the method of suturing the cut end of the small bowel into an incision in the colon. The incision in the colon is made longitudinally and is not quite so long as the diameter of the ileum. The end of the ileum is fastened into the side of the colon by four sutures, one at each end of the longitudinal incision and one at either side. As each knot is tied the suture is carried inside the colon and is left long enough to draw the line of suture out at the open extremity. The suturing is then completed inside the gut. After replacement, the serous surfaces are sutured together outside the intestine for reinforcement. The end of the colon is then closed by interrupted Lembert sutures.

After excision of the intestine the patient should have no solid food for about four days. The diet should consist of liquid easily assimilable food. On the third day a laxative can be administered, and, after the bowels move, feeding can be commenced. *J. Garland Sherrill.*

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COLONIAL SPRINGS.—Suffolk County, New York.

Post-Office.—West Deer Park. Hotel (Colonial House) new.

Access.—Viâ Long Island Railroad, 34 miles east of New York.

These springs are situated near the base of a bluff that stands about one hundred feet above the great plain of Long Island, the water rising up through a large deposit of clay in which are found considerable quantities of iron and other minerals. The location is about two hundred feet above the sea level and near the middle of the island, being 5 miles from Babylon, on the Great South Bay, and 7 miles from Huntington, on the Sound. It is said that the atmospheric temperature during the winter months will average four degrees warmer than at Lakewood, N. J. There are two springs in use, known as the "Colonial" and the "Mo-Mo-ne" Spring. The former has been known and used for many years by people in the vicinity suffering from kidney troubles. While excavating to make a reservoir for the "Mo-Mo-ne" several years since, four Indian wells were discovered two or three feet below the present surface. These were made from the trunks of the swamp aspen, or poplar—a tree of the Southern States. The trunks had been burnt out in the centre with hot stones, in the same way that the Indians employed in constructing their canoes. The smallest of the wells was left in position, while the others are on exhibition at the Colonial House. This discovery seems to prove beyond a doubt that the waters here were known to and used by the aborigines before the advent of Europeans.

The waters of the two springs were analyzed in 1894 by Professors Chandler and Pellew, of Columbia College, New York:

One United States Gallon Contains:

Solids.	Colonial Spring, Grains.	Mo-Mo-ne Spring, Grains.
Potassium sulphate	0.19	0.12
Potassium chloride	.43	.06
Sodium chloride	.80	.48
Sodium carbonate	...	.06
Calcium carbonate	.36	.09
Magnesium carbonate	.17	.13
Oxide of iron and aluminum	.02	.02
Silica	.44	.47
Organic and volatile matter	.09	.19
Total	2.50	1.62

These waters are very pure, the analysis showing but a minute proportion of organic matter. They are well qualified for domestic use. The Colonial Spring is similar to the Poland Spring of Maine. The water has a mild diuretic and tonic action. It has been found useful in kidney and bladder troubles, and may be taken in large quantities. *James K. Crook.*

COLOPHONY. See *Rosin.*

COLOR PERCEPTION, NORMAL AND SUBNORMAL.*—Normal Color Perception.—When the most extended nomenclature for color and the richest human color sense are compared with the almost incalculable numbers of ethereal vibrations that are representative of separate and special color impulses, it will be realized that every human subject has a limited power of receiving and interpreting color impressions.

The vast extent of color power possessed by some nations, the wide range of the so called Radde's color scale, so much used at the present time for commercial purposes, and the wonderful ability of the world-renowned Chevreul, all sink into insignificance when they are thought of in connection with what might be visible were the human organs of vision better developed and able to function to greater degrees.

The merest difference of number of vibratory movements—a single difference—makes a change in color, and each color change gives a different degree of sensory impulse. It is not the artificial mental division of the solar color spectrum, for example, into the well-known seven integral parts (violet, indigo, blue, green, yellow, orange, red) that should be considered. It is not the unscientific and oftentimes nonsensical anatomical construction of a color-perceiving apparatus into adapted component portions that is obligatory. Coarse specialization of receiving tip, transmitting fibre, and discharging molecule is unnecessary. Supposed peculiarities of physiological action, brought forward in order to explain well-known visual phenomena, are useless. For example, chemical chromatic and achromatic actions (Wundt); differences of excitation of the retinal rods and cones (Lederer); localized vibratory actions in the macular region (Salom); vibration movements of the retinal sheet (Delbouef); movable color molecules in the cerebral color centres (Krenchel); paired anachromatic and katachromatic cones (Preyer); and the better known three-fibre and triple-molecule theories claimed to be outgrowths of Wünsch's hypothesis (Young-Helmholtz, Maxwell, Raehlmann, and Helmholtz), as well as the most remarkable supposed dissimilative and assimilative powers of paired sensations, said to have found birth in Schopenhauer's theory of color vision (Hering), constituting the most important hypotheses that have been offered—are all fallacious and unscientific. These and their many thoughtlessly accepted modifications are in the main so ridiculous when they are made correlatively to apply to the other special senses, that it seems remarkable, considering the present state of minute research, that they are allowed to remain so frequently unchallenged and unattacked.

The fact is, that every difference of color wave gives a different degree of physical impact, as it were, upon the one and the same receiving tip. Each such tip receives such an impression, and in strict conformance with its individual ability transforms the impress into an equivalent active energy. Each transmitting fibre carries this transformed energy to its anatomical representative in the cerebral cortex, in which situation it is ready to be received and interpreted by a series of complicated sensorial acts.

The most highly specialized receiving, transmitting, and discharging portions of the color apparatus are those that have their peripheral terminations situated in the macular regions of the eyeball, at the internal ending of what is known as the direct axis of vision. These, as well as the other receiving tips or peripheral terminations of the sensory neurones, are bathed or dipped, as it were, to different degrees in a number of photo-chemical substances which during their activity are being both constantly used and renewed. The newly made energies rush centripetally along the transmitting portions of their related neuronic tissues to their connected internal prolongations in the occipital cortex, and thus produce corresponding changes in the cortical structures by which momentary molecular mosaics that are the exact representatives of the component parts of the peripherally placed retinal pictures, are obtained.

Each element of the neuronic system has its individual duty to perform, and each portion of every particular neurone does its specific work; so that, as a finite result, a composite expression of that part of the external world which is visible is placed in a position for perception and recognition.

As each particular sensory neurone has its relative power, and as the most highly developed ones are situated directly in the visual axis, color perception is found to be the best along the line of fixation; red, for example, being the farthest seen, followed by yellow, blue, and green. Moreover, as might be expected, each sensory neurone accomplishes its work with a certain degree of celerity: for instance, yellow is said to be the most quickly seen, followed by blue, red, and green.

From this central area of highest grade of perception of color difference and amount of color saturation, a more extensive area in which the less and less difficult of color changes are successively lost, extends in all directions. This field of color vision, as it is called, extends normally to its greatest breadth down and out. The order of the field widths, as seen clinically for a few of the colors that are the most commonly employed, are green, red, blue, yellow, and white.

As with the individual sensory neurones, so with the various composite series. There is the greatest difference in the color-perception value of different individuals. Visual apparatuses are just as unlike as are any of the other physical structures. The working power and the resultant physiological expression of the sensory acts are peculiar and idiocratic for similar degrees and amounts of external stimuli. Each apparatus holds its own grade of physical material and hence possesses its independent value of working force. This constitutes a true expression of the entire worth of the color apparatus. It is the sum total of its powers. It represents the greatest capability of the color-perceiving elements to be acted upon.

Totally different from this is the limitation of color perception that is dependent upon deficient functional activity as the result of want of education in color and lack of color training. Racial differences, sexual peculiarities, and constant association with color differentiation, all play their effective rôles in this type of defect. Many nations will possess finer color differentiation just as long as their inhabitants continue to employ the recognition of color as one of their most important means of existence. Women, who as a rule live among color changes more continuously than men, must perforce almost constantly exceed the male sex in their color powers; while workers in color, no matter of what sex or nation, must necessarily acquire a much better color sense than those whose occupations do not require the determination of color differences. This can be well understood when it is considered that an educated musician is able to enjoy musical sounds that are ignored and in fact unheard by those who have less trained auditory apparatuses. In other words, education and training bring into recognized activity neuronic elements of color seeing and sound hearing that usually remain dormant and unemployed.

Color perception may be produced in several ways; that is, the neuronic elements may be excited into action by stimuli of various types and from different places. The visual sensory neurones, composed of physical elements that are adapted for the production of visible color, will, no matter in what way excited, give visual perception results. They are made for this purpose alone. In every such response there is a dual act: first, the employment of sufficient material to produce the visibility of the impinging color impulse or otherwise provoked stimulus; and second, the reformation of an adequate amount of substance to allow the immediate perception of a fresh impression.

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* This brief article is a practical expression of much individual experimental work on the subject, as well as a compilation of the many minor communications that I have from time to time published in the medical press. A more detailed account is reserved for an extended monograph that I am preparing for early publication.

Ordinarily, the impulse is received directly through the peripheral tips of the neurones in the macular regions of the ocular retina, giving what is known as direct vision. At the same time, a whole series of surrounding impulses are acting upon the circummacular regions of the same retinæ, producing indirect vision; the two composing what is clinically termed fields of vision and constituting the entire amount of physiological action of the commonly employed visual apparatus.

Symptomatic color expressions of inadequacy in this process, resulting from the response of remaining neuronic energies after perception of a primary impulse has taken place and before any fresh material in the sensory neurones has been obtained, are known as subjective after-color perception (so-called complementary colors, because the energy left is always equal to the subjective complement of the primarily seen color).* These are many and most varied. For example, if a small red wafer be superimposed upon a sheet of white paper, and the eye made to gaze intently upon it for a few seconds' time, the underlying white areas will, when the wafer is suddenly removed, appear green in tint. Here the sensory neurones, having been excited and employed so as to allow the perception of a red area in a white field, have suddenly exposed to them an area (previously occupied by the red) necessitating a greater degree of energy than that which was requisite for the perception of the red. The neurones used for this area, thus lowered in their powers by the red, give answer to their utmost ability, which, in this example, is merely sufficient to produce the perception of green.

Again, among what is known as simultaneous contrast colors, the answer is similar. Here the contiguous portions of the peripheral parts of the sensory neurones are unequally excited at the same moment, giving rise, as the conditions vary, to all manner of combinations of adjacent objective and subjective colorations. So, too, with the alternating subjective after-colors, or "multiple complements" as they are termed, in which alternating subjective perceptions of red and green, for instance, are set into activity. These are most probably dependent upon momentary regains and discharges of neuronic energies that are equal at the moment for the perception of the colors recognized.

If color perception be produced by an irritant other than color stimulus, no matter in what portion of the sensory neurones it may be situated, the result is known as subjective color. Blows upon the eyeball, irritation of the peripheral tips in the retina through inflammation in the contiguous tissues, vascular changes, neural disorder—all these, for example, serve as etiological factors in the production of this form of neuronic activity.

SUBNORMAL COLOR PERCEPTION.—As previously stated, every human visual organ is adequate for the perception of but few of the color differences that are resident in the spectrum of the sun or other illuminant; but although each color-perceiving apparatus has its limitations, yet, as can be well understood, there is an average perception below which, should any individual set of organs fall, it must be considered as having reached a subnormal stage and should be placed among the defective.

Forming but a part of so-called abnormal color vision (which is not infrequently abnormally increased in certain types and stages of organic disorder and disease), it expresses itself by a diminution of the color fields, a lessening of saturation or intensity of the colors themselves, and a loss of differential coloration.

Known and recognized for many years past, it at first offered itself as a mere literary curiosity. Later, better understood, it became a well-appreciated fact.

Among the earliest reported cases mention may be made of that seen by Tuberville, referred to in a letter written to the Royal Society in London in 1684. In this communication he says, "a maid two-and-twenty years old came to me from Banbury, who could see very well, but no color besides black and white," etc.*

Nearly one hundred years later, in 1777, Huddart gave a detailed account of an intelligent shoemaker, one of three brothers with congenital color defect, who at about four years of age had his attention first called to his infirmity by his being unable to recognize a peculiarity which others attached to a certain stocking by calling it red. Later, he observed that he was unable to differentiate red cherries from green leaves, except by form. It was afterward determined by scientific investigation that he was almost wholly devoid of color sense.†

Two years later, possibly attracted by Huddart's description, Scott reported his own case in which yellow and deep blue were alone readily distinguished.

Fifteen years after this, appeared the report of the well-known historic case of the chemist Dalton. Occasionally making a study of botany he accidentally discovered that the color of the flower Geranium zonale, which is pink, appeared "sky blue" by day and "red" by night. Pursuing a series of investigations with the solar spectrum he found that he could not see any other colors than "yellow" and "blue" or "yellow," "blue," and "purple." The portion which is ordinarily seen as red appeared to him as "little more than a shade or defect of light."

Passing on to Nicholl's case of a "red-green" blind boy of eleven years of age, and a forty-nine-year-old man in whom "the different shades of red and green, I know not to which they belong: but when they are before me, I see a difference in the shade," reported in 1816 and 1818, we are brought to Hays' Wills' Hospital case seen in 1840, Earle's family history in 1845, and Wilson's Inglis case noted in 1855.

It is useless, however, to argue that the cultivation of the color sense was carried as far among the ancients as it is at the present time. Pliny, in speaking of the paintings of Apelles, who flourished about three hundred years before Christ, says "that all these wonderful paintings, which were the admiration of all mankind, were painted only with the four primitive colors"; and Cicero, in one of his books "De Oratore," makes Crassus, in a conversation upon the comparative beauty of ancient and modern painting, say, "Let us, for instance, consider our modern paintings. Can anything be more splendid and lively? What beauty, what variety of colors! How superior are they in this point to those of the ancients!" And Dionysius Halicarnassensis, who flourished about the time of Augustus, remarked that "the ancients were great designers, and understood perfectly all the grace and fervor of expression, though their coloring was simple and little various. But the modern painters, who excel in coloring and shades, are vastly far from designing so well," etc.

At present, all subnormal color perception is subdivided into two great groupings. The first is the congenital, consisting in a want of properly formed physical material: a true structural incapability as it were. The second is the acquired, in which either a properly made material or even a badly formed structure is lowered in its vitality by injury or disease occurring during its functional existence; a traumatic or pathological change taking place in the working lifetime of the color apparatus. The former is fixed and irremediable. The latter's betterment is always in direct relation with the nature, the seat, and the progress of the causative condition.

At the present time, the congenital form is found in about one out of every thirty males, and in about one in every thousand or more females. Heredity plays an important part in its production. Horner's law, based upon his remarkable series of ancestral cases, is quite frequently noticed.

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* This is well corroborated by the experiments of Herschel, Wartman, and Kelland, in which it was shown "that the complements no more than the primaries showed to color-blind as they do to normal eyes."

* Dawbeney's case of a thirty-two- or thirty-three-year-old woman is probably the same one. Spurzheim describes a series of similar cases in one family.

† In 1779 Rozier makes mention of Calarean's inability to distinguish between red and green.

Wilson, Wartmann, and Jeffries have all noted a peculiar facial expression, principally ocular, in these cases.

The current naming of the various types of subnormal color perception depends upon whether the affected subject is designated by the coarse color differentiation he fails in or by those colors which he is able to recognize similarly with the average normally sighted. Wilson, Rose, Holmgren, and others obtain their systems of naming from the unrecognized color or colors, while Mauthner and Szokalski, for example, base their nomenclature divisions upon the colors which remain visible.

The naming of the condition in general has been just as varied. The many euphonious pure and mongrel coinages should all be discontinued, as they are, as a rule, both useless and inexpressive. Resource should be had to the comprehensive term "subnormal color perception," reserving the naming of the degree of the defect to a numerical value based upon the average relative ease of color differentiation, which could be easily obtained and would give an absolute answer to the grade of the defect, just as is done at present in expressing the valuation of direct vision for form.

In the congenital type, the preponderance of the number of cases begins with green and red. Blue and yellow blindness is exceptionally seen; while the so-called total variety—in which nothing remains but a photographic world, as in Magnus' well-known case of a school teacher who compared her color spectrum with a very finely executed lead-pencil shading growing darker from the natrium line (a very sharply defined yellow line in yellow) toward the unshortened end—in such delicate graduations that the different gray wools were not sufficient to represent them—is excessively rare.

Should green and red be the two gross color differentiations that have disappeared, the position of the green in the solar spectrum will be, as a rule, occupied by a gray zone.

In the acquired form, green followed by red, blue, and yellow is the order of color loss that is usually found. If, in cases of gross inflammatory changes in the optic nerve and surrounding retina, a subsidence of the gross pathological changes takes place, there is frequently a temporary or a permanent regain of the colors—commencing with yellow, blue, red, and green; but the color sense is never brought back to the same degree as it originally existed. This, however, in the majority of cases, is sooner or later followed by a permanent though oftentimes extremely gradual second loss of color changes which take place in their original order of progression.

The association of congenital defects in other sensory organs with subnormal color perception is very rare. Jeffries' most interesting instance of a celebrated poet who, besides being unable to distinguish many colors, was almost entirely incapable of differentiating musical sounds, is an excellent example. As Jeffries says: "The kaleidoscope of nature and the harmonicon of art are the Utopias of his mind. The magic hues developed by the prism, the iridescence of shells and minerals, the inimitable colors of the beasts and birds of tropical climates, the verdure of the fields of spring, the splendor of the autumnal foliage of the forests, the myriad hues of flowers—all these, it would appear, are comparatively 'as a sealed book' to him. Yet from his writings no evidence of this can be detected."

We are now brought to the question, What does a subject with subnormal color perception see? If we should ask a red-blind person to look at a piece of red worsted or a stick of red sealing wax, what will he tell us? He says he notices a peculiar difference in its shade which characterizes it from all other sensations, and his description of it will depend entirely upon the extent and position of his visible color spectrum. It must be remembered that he has no language for red as we see it; although he may learn by association to call a red object by its proper color name, yet he is unable to recognize that peculiarity which to a normal eye so strongly contrasts it with the other colors; the same being true of all the other forms of color blindness. Geissler says, for the red-blind the landscape has the character of autumn. A sunset or the beauty of our red flowers, with their various tones of blue and violet, he is perfectly indifferent to; but his fine sense for gray-white-blue shadows gives to glacial views a greater charm than to the normal eye.

Why should he be pitied? He has never known the color. It is to him what an unknown sense might be to us: we are contented, not knowing better, and he the same. Again, his bichromatic world, for example, with its innumerable shades, may be a greater source of delight than our recognition of another color sensation.

There are many occupations open to the "color-blind," and even a few in which his infirmity serves as an actual advantage,—in photography and lithography, wood-cut, steel- and copper-plate engraving, and printing: in all of these, in which there is the want of an organ able accurately to differentiate between the many shades, he becomes an adept. Why could not an artist with subnormal color perception limit his productions to winter landscapes, lofty mountain scenery, studies in grays—thus obtaining wonderful and almost life-like facsimiles of nature? Why need he despair and complain when such a field of study and such a source of pleasure is thrown open to him—a character of work in which, by necessity, he must surpass all others who do not possess this now properly termed, to him, an advantage?

From this, however, it will be understood that not only is the recognition of the condition of importance to the individual, but it is quite frequently of value to the public at large. Placed in a position so as to misinterpret color signs, such subjects oftentimes become a menace to the safety of both human life and property.

For the practical recognition of the condition there have been many devices. These plans have been based upon three well-known methods: First, direct comparison of pigment colors; second, direct comparison of spectral colors; and third, the study of subjective after-color (complementary color).

The first, which is the most important and the one that is in common use for ordinary clinical purposes to-day, is best known by the wools of Holmgren that were borrowed from the papers of Seebeck and the worsteds of Wilson. Modified in all manner of ways by assortments of fixed colors that have been arbitrarily and even foolishly arranged upon cards, sticks, spools, cones, discs, and other articles, it has suffered the most varied of vicissitudes only to come back to the original plan of loose-wool selection that was strenously sought for by both Wilson and Holmgren.

Maxwell's and Woinow's revolving discs, Hierlinger's and Magnus' tables; Lip's color triangles; the optotypi of Snellen; the color tables of von Reuss, Daae, and Roberts; the yarn-covered spools of Schenke; Kolbe's truncated cone, the pseudo-isochromatic wools of Donders, the embroidery patterns of Cohn, and the stick of Thomson, constitute the majority of the devices that have been successively championed and upheld by their individual contrivers.

The more or less fixity of the tests, thus limiting the number of colors from which a choice might be taken; the arbitrary relationship of the component parts without any scientific reason, thus allowing them to fail to express the many percentages of lowered color-vision presented by the different candidates for examination, and permitting numbers of persons affected with subnormal color perception to escape by reason of the confusion, colors not being equal to the exact amount of the resident color error; as well as the liability of the methods to become known and understood, and thus rendered practically worthless when pursued among a great number of similarly placed individuals, are some of the main reasons why these latter plans cannot be satisfactorily employed.

Another plan by the same method is the placing of colored powders in homœopathic vials as pursued by Mauthner and Cohn. This has been done in order that the candidate shall not be able to differentiate color changes in yarns, worsteds, and wools by the supplemental use of the senses of touch and smell. That the objections these authors offer to the free handling of colored wools is in measure true there can be no doubt; a fact that as long ago as 1849 was pointed out by Wartman, who made mention of a man with well-marked subnormal color perception, who "corrected by the help of touch a part of the erroneous judgments which he formed regarding colors." This power of the possessor of subnormal color-perception was reproven only six years later by Wilson, who justly attributed it to a delicacy of the tactile sense in discriminating between the harshness and the smoothness of variously colored dyes, and said "a wool dyed with a mineral green might thus be distinguished by the touch from one dyed with a vegetable, although the color-blind eye could detect no difference between their tints."

These observations have in a measure been confirmed by personal research by myself among the absolutely blind. I have determined without a doubt that a few of the most intelligent and dexterous of such subjects possess the power of differentiating the dark-colored wools from the light ones by a feeling of harshess of the dark skeins; although to obtain anything like a majority of proper results necessitated quite a long and frequent association among such objects. In further confirmation, I have found that some of the wools were detected by the sense of smell, the white ones having "a woolly odor."

The second method (direct comparison of spectral color) unfortunately cannot be brought into every-day employment as an ordinary test for the quick detection of lowered color sense, although it can be made to serve a useful purpose in cases requiring more than ordinary observation, as among persons under judicial action. The apparatus is expensive; its mechanism is complicated and liable to become disarranged; both the examiner and the candidate must possess the necessary intelligence to handle the instrument; and the dealing with spectral colors which are not the ones that the examiner is brought in daily touch with are some of the reasons why this plan must be relegated to the determination of a few selected cases.

The double spectroscope of Hirschberg, the polariscope of Rose, and the not very euphoniously named chromatophotoptometer of Chibret are among the principal and most ingenious contrivances employed in the method.

The third method is practically useless. Much time and energy have been expended upon it. Contrivances of all kinds to show simultaneous and successive contrast colors have been devised. Prominent among them are the Heidelberg and Pflüger color books, Scina's mirror-contrast apparatus, Stilling's so-called chromatoskiameter, and Cohn's chromaskiopticon. Unfortunately, in this series of experiments, vague subjective colors are dealt with; uncertain color intensities and, in fact, absolute changes of color vibration are used; and the adjustments of the instrumental technique are frequently uncertain and misleading.

In addition, the examinate is required to compare the subjective color with some known series of colors such as wools and papers, which might as well have been done primarily by the ordinary method of loose-wool selection.

For general clinical purposes, some scientifically arranged collection of loose wools is by far the best, the cheapest, and the most easily handled material that can be used for testing the value of the color sense.

The series brought forward by myself are composed of a number of loose test and match skeins that have been carefully graded to equal relative intensities. Each color has its tint expressed in such a way that while its value is unintelligible to those who are being examined, an exact index of the character and the amount of color perception of the subject is given. The wools themselves have been made of one grade of manufacture and are dyed with vegetable materials. They can be employed by any educated layman (even though he himself have subnormal color perception), and with them records of all passing color changes may be kept for future comparison.

Broad diffuse daylight is necessary. A black surface upon which the wools are to be promiscuously thrown should be employed. One eye of the examinate is to be tried at a time. The candidate is requested to match the five (green, rose, red, blue, and yellow) test skeins in any order that may be desired. The letterings upon the tags of the chosen wools are to be registered upon appropriately arranged blanks.

For the study of the color sense in railway and marine services resource must be had to another plan. This, which I have pointed out, consists in placing the candidate in the actual position in which he is afterward expected to discern properly the colors employed for signalling purposes. Miniature lanterns containing ungauged arbitrary color differences, such as those of Thomson and Williams, held fifteen or twenty feet away from the subject, are most uncertain. The candidate must be tested with adaptations of apparatus that are as nearly as possible like those which are used under ordinary circumstances—*i.e.*, when he is employed at his work. The testing must be done under the actual conditions which are supposed to exist while the candidate's color sense is protecting life and property.

As early as 1855, Wilson determined, as the result of numerous examples and experiments, that not only could color be recognized correctly at short distances and not distinguished at longer ones where such colors were plainly discernible to the normal-sighted, but he also found that the sensitiveness to the colors, while being gazed at, became more quickly lost as they were removed from the eye of the "color-blind" than when they were removed from the unimpaired visual organ. This, which he aptly termed "chromic myopia" or "short-sightedness to color," expresses in a word or two why candidates for positions necessitating color recognition at comparatively long distances, or what I have designated as "safety distances," cannot be considered as adequately determined when they have been tested by the ordinary methods of loose-wool selection or other near-at-hand tests.

Examination of such candidates at safe distances becomes a necessity. The determination of the color sense along the visual line, or what is generally known as foveal vision, is the main requisite, this being particularly so when it is considered that in the acquired types of color defects produced by the introduction of toxic agents, such as tobacco and alcohol, into the system, it is in the central area of the visual field that the color becomes diminished in saturation or is lost.* The findings at one or even two metres' distance are in this character of cases worse than useless: they are dangerous. As just said, the degree and the amount of color sense must be known when the organs of vision are placed under the same circumstances as they would be when it becomes necessary that they should be the sole means for the avoidance of threatened accident or the prevention of imminent danger.

Laden engines, for example, moving with the rapidity of twenty to thirty-five metres each second, or so-called traction trolleys which run at such high rates of speed, would be propelled into destruction long before any engineer with "chromic myopia" could check their speed. The lesson for the recognition of the customarily used signal must be made at a distance which is sufficient for a proper control of the moving mass. It must be known that the candidate for such work is able to recognize color at long distances. To accomplish this purpose, the candidate must be made to select definite kinds and intensities of both reflected color by daylight and transmitted color by artificial light stimulus placed at distances that are requisite for safety in after-work.

The test that I have applied for this purpose among railway employees consists in a fixed apparatus which can be placed anywhere upon the company's property. Wooden frames containing properly and proportionately sized match and confusion colors of bunting for daylight work, or illuminated plates and lanterns of transmitted color for bad weather or night, are to be lined in a row in any order whatsoever, just as the wools are promiscuously thrown upon a table. The five test colors similar to the ones I have employed for the near tests are placed in an upper tier. Just as with the near-work tests the candidate employs one eye at a time. This done, he is then made successively to designate by the actual position of the color in the lower line the nearest numerical match to each of the upper test colors. This selection by number is to be handed to the examiner, who after having obtained the true color names of the numbers chosen for the occasion by the attendant, places the choosings upon suitable blanks for permanent registry.

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* For the determination of this condition at close range, Abney's pellet test is most useful.

To obtain the different percentages of light stimulus and to simulate as nearly as possible changes in character of weather (fog, rain, etc.), variously tinted glasses can be used, although preferably the candidate can by this plan be tested during the actual states of weather.

An experimental track with a number of open switches so arranged that the sidings pass directly beneath certain colors would be useful for practically testing the color vision that is necessary to employ while running locomotives, trolley cars, etc., at full and even high rates of speed.

In marine service the danger is increased. All vessels carry a green light on the starboard side, and a red light on the port, each being so boxed as to be seen forward and amidships. These are accompanied by a low white forelight, and sometimes by a high white aftlight. Hence, by comparison, a vessel's course can be easily distinguished. If, under such conditions, however, a heavy fog, or snow, or a rainstorm were to exist, it can be understood how an official with subnormal color perception, judging these important color distinctions by their intensities alone during the best of weather, is placed in a position that practically amounts to the absence of signals.

For the detection of the defect in marine and naval work, quite simple modifications and adaptations of color testing by which adequate data may be obtained can be made.

In all railway or marine testing, care must be taken that both the test and the later working colors* should be graded in proportionate sizes and relative intensities of tone, thus giving similar distance values to every color used in the tests. That this should be done will be at once appreciated when it is remembered that different degrees of vividity of color areas of equal size produce such alterations in impressions that the colors give rise to false perceptions regarding their relative distances from one another.

Again, the dominant colors of the reflecting surface near which the test is made (as, for instance, the green of a hillside, the gray and white of a mountain top, and the blue of an ocean surface) all play important rôles as to the value of the tests.

The character of the illuminant itself is of the greatest importance. The blue of diffuse daylight, the greenish or nearly white tint of incandescent zirconia or metallic oxide mantles, the varying degrees of yellow rays from oils, illuminating gas and carbon loops, and the purples of free arcs of electricity, show how variable in tint color areas must become when exposed to these different agents.

Endeavors should be made to try to overcome the totally different values that are empirically placed upon the hues of the test colors themselves. This might be done by assuming pigment hues which are equivalent, with the midway bands in the corresponding portions of the solar spectrum. Such selections could be determined mathematically and analytically by an international commission, and reproduced in pigments from a consensus of examination by national or sectional sub-committees of competent observers possessing normal color vision.* These pigments could then be used for signal boards, signal lights, and test colors in any given locality.

There should not be any degree of standard in regard to the color capacity of any railway or marine official whose routine duty consists in the differentiation of color. Such positions are relatively so few when compared with the great supply of available candidates, and the responsibilities are so grave, that no exception should be made. Such candidates should be rejected without a particle of sentiment.

The lack of systematic and periodic re-examination of the color sense is another great evil. This inefficiency in color testing is most reprehensible. After every case of severe injury or attack of illness that might in any way be likely to produce visual disturbance, an examination should be made; and, moreover, among those who are known by strict, and yet silent surveillance, to use any toxic agents, such as tobacco and alcohol, the tests should be both painstakingly and frequently tried.

The increased responsibility acquired by civil service, in which older subjects who are more prone to exhibit acquired color defects than younger ones, and who are at times given positions that usually necessitate the greater employment of normal color organs than before, should be especially subjected to careful periodic repetitions of some of the more important measures which are employed for the determination of the amount and degree of the color sense.

Losses of color in the so-called visual fields are quite common. They assume many forms, and quite frequently are expressive of definite types of both local and general disease.

Symptomatic in character, they oftentimes help demonstrate the exact position of intracranial disturbance, prove the actual functioning condition of inflamed and degenerating local tissues, give answer to situations of gross orbital change, and serve to distinguish functional complaint from organic disorder.

They are obtained in various ways: first, by ruled blackboards upon which small colored objects are carried toward central fixing points; second, by perimeters, which are mere mechanical contrivances for carrying small areas of color inward upon graduated metallic arcs toward fixed central points: and third, by similar movements of the outstretched fingers, lighted tapers, and focussing mirrors.

To be strictly accurate they should be repeated under varying conditions of time, luminosity, distance, and position. *Charles A. Oliver.*

COLOR PERCEPTION, SUBNORMAL; RAILWAY AND MARINE EXAMINATIONS.—The examinations made to detect cases of defective color perception were so unsatisfactory in the railway and marine service that in 1890 the British Board of Trade asked the Royal Society, "What is the best test for color blindness?"

A committee was appointed, including some of the most distinguished members of the Society, and after two years' work they unanimously reported as follows:

"1. That the Board of Trade, or some other central authority, should schedule certain employments in the mercantile marine and on railways, the filling of which by persons whose vision is defective either for color or form, or who are ignorant of the names of colors, would involve danger to life and property.

"2. That the proper testing, both for color and form, of all candidates for such employments should be compulsory.

"3. That the testing should be entrusted to examiners certificated by the central authority.

"4. That the test for color vision should be that of Holmgren, the sets of wools being approved by the central authority before use, especially as to the correctness of the three test colors, and also of the confusion colors.

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* Unfortunately, it has been found by repeated experiment that the very colors which are the earliest and the easiest lost are the ones that must be used for practical purposes.

* Lovibond's tintometer, Rood's flicker photometer, or Abney's color-patch apparatus might be of value in this direction.

If the test be satisfactorily passed, it should be followed by the candidate being required to name without hesitation the colors which are employed as signals or lights, and also white light.

"5. That the tests for form should be those of Snellen, and that they should be carried out as laid down in Appendix 6. It would probably in most cases suffice if half normal vision in each eye were required.

"6. That a candidate rejected for any of the specified employments should have a right of appeal to an expert approved by the central authority, whose decision should be final.

"7. That a candidate who is rejected for naming colors wrongly, but who has been proved to possess normal color vision, should be allowed to be re-examined after a proper interval of time.

"8. That a certificate of the candidate's color vision and form vision according to the appointed tests, and his capacity for naming the signal colors, should be given by the examiner; and that a schedule of persons examined, showing the results, together with the nature of the employments for which the examinations were held, should be sent annually to the central authority.

"9. That every third year, or oftener, persons filling the scheduled employments should be examined for form vision.

"10. That the tests in use, and the mode of conducting examinations at the different testing stations, should be inspected periodically by a scientific expert, appointed for that purpose by the central authority.

"11. That the colors used for lights on board ship, and for lamp signals on railways, should, so far as possible, be uniform, and that glasses of the same color as the green and red sealed pattern glasses of the Royal Navy, should be generally adopted.

"12. That in case of judicial inquiries as to collisions or accidents, witnesses giving evidence as to the nature or position of colored signals or lights should be themselves tested for color and form vision."

In a further discussion of the subject the committee make a number of statements which it is well to keep in mind. "The variations in the amount of this deficiency in color perception are numerous, and when small are often exceedingly difficult to classify. We have to regard these deviations from normal vision more from a practical than from a theoretical standpoint, and in testing for them we have to take the broad view that the color blindness which has to be detected is that which may be dangerous to the public in the industries already mentioned." "In a testing room, when signal lights are used as tests, color-blind persons may possibly be able, with practice, to name the different colored signals correctly, recognizing them by their relative brightness, and by their dilution with neutral color. The practical tests the committee have carried out confirm this view; men who are absolutely color-blind having passed such a test without being detected. It might be supposed that if the colors of signals could be rightly recognized in the testing room they would be equally well recognized elsewhere. It must, however, be recollected that the atmospheric conditions of the testing room are often very different from those which are found outside. As a rule any judgment of the color of a signal which depended on its brightness would be fallacious. A dirty glass or a misty atmosphere would introduce a liability to error. The red signal of danger might then be mistaken for the green or white signal of safety, and vice versa. It must also be remembered that a signal light, as a rule, has no white light adjacent to it with which to compare it, and thus a decision as to whether a light is neutral or slightly colored has to be arrived at under great disadvantages." "In the color blindness induced by disease or injury, although the loss of color sense is usually confined to a small area of the retina, yet as it is the central area and therefore the part on which the image of small objects naturally falls, the danger of mistaking a color is as great, and even more so than in congenital color blindness." "The standard test colors which have been approved by Professor Holmgren have been referred to the spectrum. The first standard is a light green color, which can be matched with a green in the spectrum (λ 5660) when forty per cent. of white is added. The second standard skein is light purple or pink, and its complementary color is a green in the spectrum (λ 5100). The color is diluted with about forty per cent. of white."

"All tests in which the wools are suspended from a bar, even though the test skeins may be of proper color and tone, should be avoided, since the order of arrangement might be ascertained by some means or another by those who are tested. It is quite true that the order might be changed: but in an examination of this character, where large numbers may be under trial, any frequent changing of the order would be impracticable, and hence there would be no security that the test was efficient. The same objection applies to all diagrams of color which the examined are required to match with standard colors." "The Committee would not insist upon the examiner being a medical practitioner, but it is probable that a medical training would be of advantage. They are further of opinion that there should be a periodic inspection of the different testing stations by duly qualified ophthalmic surgeons, who should report upon the condition of the testing appliances and upon the mode in which the tests are carried out: and who might be the authorities to whom an appeal from a rejected candidate should be referred. In no case should any test be allowed in substitution of those recommended, though supplementary tests might be tried if desired. The passing or rejection of the candidate should always be based on the tests which have been laid down." In 1892 a Committee of the British Medical Association made a report on "The Efficient Control of Railway Servants' Eyesight," in which they recommended: "2. That the test for color sense should be that of Holmgren carried out in strict accordance with his direction. After this test has been passed the candidate should be required to recognize and name promptly the colors used in signalling. We wish to emphasize the importance of employing glass of standard color in railway signal lamps: as recommended by the Committee of the Royal Society."

In Holland the rules governing the examination of the eyes of the employees of the Dutch state railways are more complete than in any other country. They were arranged by Prof. H. Snellen, who is also the consulting ophthalmic surgeon, to whom all cases of doubt are referred, but the ordinary examinations are made by ophthalmic surgeons at various convenient places on the lines. Article 10 provides that "The color sense is to be estimated—(*a*) qualitatively, by pseudo-isochromatic tables of Stilling, and with wools, according to Holmgren's method; (*b*) quantitatively, by Donders' method, which must be applied in every instance without exception."

In a small and compact country like Holland, it is possible to carry out methods of examination which would not be practicable in the United States, where one railroad company in several instances operates more than seven thousand miles of track, and has an army of employees widely scattered along its lines. My experience with two large railways in the United States, the Burlington and the New Haven systems, has shown that very good results can be obtained by having the examinations for color perception made in accordance with carefully prepared instructions, drawn up by an ophthalmic surgeon who has had some experience in these matters, the routine examinations being made, in one case by the medical examiners of the road, and in the other case by employees selected for this work on account of their good judgment and intelligence; in each case the examiners were first carefully tested to make sure that their color perception was normal, they were then instructed in the methods to be followed in making the examinations, and were provided with printed instructions and blanks on which the records of the examinations were to be made, and with the necessary materials for making the tests, these materials having been previously approved by the ophthalmic surgeon. Cases of doubt were referred to him, and on one road the reports of all examinations were sent to him for final approval. In this way a check could be kept on the work of all the examiners, and uniformity of standards and tests secured.

In order to have the approval of the operating officers of the great transportation lines, and to obtain their consent to the adoption of these examinations, the tests used must be simple and efficient, and in some portion of the examination they should correspond as closely as possible to the actual conditions of service. The record of the examination should be in such shape that, if necessary, the actual results of the test can be reproduced at a future time; in this way both the company and the men have better protection, for if a man is rejected he does not have to rely only on the word of the examiner that his color sense is defective, but his record will show wherein he has failed; and in case of accident the company can show from the record that the accident did not result from any defect in the color perception of the men concerned.

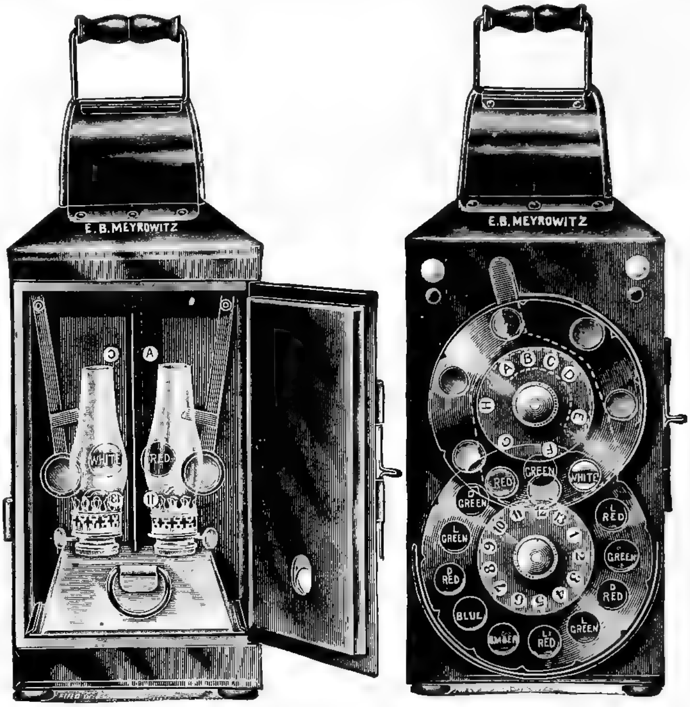

FIG. 1469.– Lantern used on the State Railways of Belgium, on the New York, New Haven and Hartford System, and on some other American railroads, for making ordinary railroad examinations.

For the last ten years I have been using sets of Holmgren's worsteds in which all the reds and greens have odd numbers, and the confusion colors even numbers; there are, however, only reds and greens enough in the Holmgren sets of one hundred and twenty-five colors to carry this numbering to 100, and the remaining twenty-five colors, including most of the yellows, are designated by letters. The first forty colors in the set have been given the same numbers as the corresponding colors on the Thomson stick, which was used on these two roads before the Holmgren test was adopted; in this way the records of the first forty numbers, both before and after the change, refer to the same colors. Small numbers are stamped on aluminum tags which are wired to the colored skeins and lie concealed in the worsted, so that the numbers are not seen by the person being examined; but after he has made his selection of the colors which look to him like the test skein, the examiner looks up the tag on each skein and makes a record of the numbers chosen. At the central office, where the reports of all the examinations are received, a standard set of worsteds is kept, sewed in numerical order on a large piece of white cloth, and in case it is desired to show from the recorded numbers all the colors that have been selected in any case, it can be readily done by reference to this set. When not in use this standard set is to be kept protected from the light, dust, and moisture. In most cases, however, it can be seen at a glance from the recorded number whether the Holmgren test has been passed successfully or not. Only two test skeins are used, the green for the general determination of the fact of defective color sense, and the rose, or light purple, to show whether the defect is more for red or for green. In Holmgren's original set a bright red test skein was also supplied; of this Holmgren himself says, "it is not necessary for diagnosis, and only serves as a confirmation," but in my experience it has often confused the results of the former test, rather than confirmed them. A man who has shown by the former tests that he was defective in his color perception would often make no mistake with the bright red test skein, and would think he was unfairly treated because, in spite of his making no error in the last selection, he was still classed as defective in color sense. Therefore, as the bright red test skein gives no additional information it has been omitted.

In addition to the Holmgren test with colored worsteds some form of test with colored lights should be used. Arrangements should be made to vary the area of the color shown, to have red and green glasses of different shades, to have smoke and ground glasses combined with the colored glasses, to show either one light at a time or two together, and to have some simple means of recording the glass shown and the name given to it.

Some ten years ago I used a Donders lantern, but did not find it satisfactory for making ordinary railroad examinations; I therefore arranged a new form of lantern, which has been modified from time to time, and in its present shape is now used on the state railways of Belgium, on the New York, New Haven and Hartford system, and on some other American railroads.

It is a square tin lantern twelve inches high and six inches on each face. On the front are two movable discs; the lower carries the following glasses: five red and four green, of different shades, one yellow, one cobalt, one smoke and one colorless glass. The upper disc has London smoke glasses of three different shades, and some clear openings, and by revolving the discs any of these colors, alone or combined with the smoke glasses, can be shown. Between the discs is a movable diaphragm with openings of 2 mm., 6 mm., and 20 mm. in diameter, by which the area of the colored lights can be changed, and inside the lantern are ground glasses which can be used in connection with the colors, or can be drawn aside. The lamp of the lantern has two burners, screened from each other, and in front of each burner is a hole in the front of the lantern so that two colors can be shown at one time; or, by moving the upper disc, one of the openings can be closed, and only one color seen. In this way two reds, or two greens, of different intensity, or a red and green, red and white, etc., can be shown together, or any of them singly. Below each colored glass in the lower disc is a transparent number, illuminated by the lamp, so that the examiner can see it and make his record of the glass shown, but screened from the person being examined; and on the upper disc the smoke glasses are similarly designated by letters. An electric lamp has been recently made for use in this lantern. It has two incandescent lights, and in the base a series of resistance coils encased in enamel and so arranged that the intensity of the light can be varied by sending the current through more or less of the resistance, by means of a switch which projects behind the lantern. The electric lamp gives a much steadier light than the oil lamp, does not smoke, and can have its intensity varied by fixed amounts; with such a lamp those cases are more easily recognized in which the brightness of the light is depended on to recognize its color. With such a lantern the examinations can be made by day in a darkened room or at night; the colors do not fade. A large number of combinations of color and intensity can be made by means of the two discs; the size of the colored area can be varied. The ground and smoke glasses with the colors give something of the effect of fog and smoke in the air, and the illuminated numbers enable the record of the examination to be quickly and easily made. In the Donders lantern the smallest opening through which the colors are seen is 1 mm. in diameter, but in practice it is a tedious process to make a fair examination of railroad employees with this small opening at the given distance of 5 metres, or sixteen feet; and for the practical purpose of testing the color perception of the central portion of the retina it is sufficient to have the opening 2 mm. in diameter, and place the lantern at a distance of twenty feet from the person examined, which is the distance used in the tests for form vision. With colored lights the recognition of the signal does not depend on the visual angle to the same degree that it does with form signals, or letters, and under favorable conditions the color of a switch or semaphore signal can be seen at a distance of more than a mile.

In the ordinary tests with my lantern the candidate is first asked to name all the colors, as seen in pairs through the largest opening, as "right red, left green," etc.; then the upper disc is turned to close one of the openings, and the diaphragm is placed to bring its smallest hole opposite the other opening. The candidate is then asked to name the colors as seen singly, through this 2-mm. hole. In this way, even when no smoke glasses are used, the name is given to a color thirty-nine times in each test, and it is very rare to find a man who passes the lantern test and fails with the worsteds, but this will occasionally occur. On the other hand, I have had four men, in about a year and a half, who passed the worsted test, both Holmgren's and Thomson's, without difficulty, but who failed badly with the lantern. They were excessive users of tobacco, possibly with some addition of alcohol, and had a small central defect in the retina, which was so small that the retinal image from a skein of worsted held in the hand extended beyond the affected area, and the color could then be recognized at once; but with the signal light the image was formed wholly within the affected part, where its color could not be recognized.

It is not easy to fix a standard for color vision which shall exclude all the dangerous cases, and shall not exclude some men in less important positions, who may have a somewhat feeble color perception and yet not enough to make them dangerous. The rule of the New Haven road is as follows: "No person can be considered to have satisfactory color perception who calls a red light green, or a green light red, under any of the varying conditions of the lantern test; or who selects the grays, browns, or reds with the greens, as looking like the green test skein, *and* selects any of the grays, blues, violets or greens, with the rose or red colors, as looking like the rose test skein of the worsted test." A mistake of one or two confusion colors, with the green test skein, would not be sufficient to reject the applicant, but mistakes with both green and rose tests, or the confusion of red and green in the lantern test, would reject him.

The New York, New Haven, and Hartford Railroad, which operates 2,060 miles of track and has 29,000 employees, has recently put in effect a very complete set of rules to govern the examinations for vision, color sense, and hearing. These rules were drawn up by me about a year and a half ago for use on a part of their lines, and have worked so well that they have now been improved and extended over all the lines controlled by this company; and as they may serve as an example of what is intended to be a thorough and fair examination, they will be quoted in full.* The rule in regard to "test glasses" is intended to detect cases in which there is such an amount of hypermetropia as would, in the course of years with increasing presbyopia, bring the vision without glasses below the standard required. It is not so complete a test for this condition as could be desired, but it prevents a number of men from entering the engine service who, with advancing years, would find it difficult to pass the vision test. The other rules are self-explanatory. *Charles H. Williams.*

INSTRUCTIONS FOR EXAMINATION OF VISION, COLOR SENSE, AND HEARING.*

(The New York, New Haven and Hartford Railroad Company.)

Each Examiner appointed by the Division Superintendent, subject to the approval of the General Superintendent, will first be himself examined as to his vision, color sense, and hearing, and if this test is satisfactory will be instructed in the use of the following material, which will be furnished Division headquarters.

1. A set of standard test letters on cards, including cards on which semaphore signals are printed; for testing the acuteness of vision.
2. A set of cards with reading matter in print of various standard sizes, and some train orders written on the manifold copying sheets; for the reading test.
3. A set of approved Holmgren worsteds (125 colors, each with numbered tags), and a standard testing lantern, with 13 glasses of different colors, and smoke glasses, and arranged to show either one or two colors at a time; for testing the color sense.
4. A ratchet acoumeter; for the hearing test.
5. Two pairs of spectacles, one with plane glasses, the other with a convex lens of two diopters, for each eye.
6. Blank forms and certificates, for noting the result of the examinations.

The tests should be made in a well-lighted room in which a distance of 20 feet can be measured from the test type to the person to be examined. Dark shades or shutters should be provided so that the room can be darkened for the lantern test. The colored worsteds must be protected from light and dust when not in use.

In case of persons desiring to enter the service insert "App." before the proposed occupation.

Each Examiner, after filling in the results of the tests on the form T 523, will note under the head of Remarks, in each case, "satisfactory," or "not satisfactory," according as the person examined comes up to the required standard or not, and will then sign the form and forward it to the office of the General Superintendent after an impression copy has been taken in the Division Superintendent's office.

The examinations should not be hurried. Some men are nervous when undergoing these tests, and need to be given plenty of time, and to be shown that no unfair advantage is to be taken of them. Do not allow frequent interruptions nor the presence of those not concerned in the test.

Each person should be examined separately, so that no assistance can be given by sign or sound to those who are defective. Much time will be saved by having a clerk to fill in the record on form T 523, the Examiner giving him the data as the examination proceeds.

All cases of doubt should be referred to a Board consisting of the General Superintendents of the Eastern and Western Districts and Dr. Charles H. Williams.

ACUTENESS OF VISION.—Place the person to be examined so that he will not face a strong light, have him completely cover one eye by holding a card over it, pressing it firmly against the nose, taking care not to press on the covered eye; hang one of the 20-foot cards at a distance of twenty feet from him in a good clear light, but not in direct sunlight, and ask him to read the letters on the card. If he can read them correctly, or with a mistake of not more than one letter, hold up another of the 20-foot cards, and, if this is also read correctly, note on the form the distance at which the test letters are read, and underneath it the number over the smallest line of test type read correctly; in this case 20/20, or normal vision. If he cannot read the letters on the 20-foot card at twenty feet, hold up a 30-foot card, then a 40-foot card, etc., until letters are found that he can read; if he cannot read the 50-foot letters at twenty feet let him approach the card until he can see them, or the fact is shown that he cannot see them at any distance. If the letters on the 40-foot line are the smallest that can be seen with this eye at 20 feet, its vision will be noted as 20/40 of normal, the numerator of the fraction being the distance at which the letters are read correctly, and the denominator being the number of feet printed above the smallest line that can be read,—that is, the distance at which they ought to be read correctly by the normal eye.

Repeat this test with the second eye, the first being covered in its turn. If the vision is less than normal, repeat the test with both eyes uncovered and open, but if the vision is normal in each eye omit the test with both eyes open.

These tests are to be made without glasses, except as otherwise specified. In case glasses are worn, test first without the glasses and then repeat the test with the glasses, noting on the form T 523, under the head of Remarks, the vision with the glasses.

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* The test letters and cards, the tagged Holmgren worsteds, the spectacles and the ratchet acoumeter can be obtained from Millar & Weltch, 38 West Street, Boston, Mass. The lantern can be had from the maker, Peter Gray, 12 Marshall Street, Boston, or from E. B. Meyrowitz, 104 East 23d Street, New York.

POSITION SIGNAL TEST.—Place one of the cards with the semaphore signals at a distance of 20 feet, as in the first vision test, and with each eye separately have the person being examined read the signals, as stop or proceed, beginning at one end of the card with one eye, and at the other end of the card with the other eye. Repeat the test with another of the semaphore cards, with both eyes open, and note the distance in feet at which the signals can be read correctly without glasses. The position signal test need not be used for those desiring to enter the service, nor unless the vision is less than 20/20.

READING TEST.—Note the smallest size of print read correctly at the ordinary distance of about 18 inches, either with or without glasses, also whether manifold train orders can be read correctly at that distance.

TEST GLASSES.—In the case of men making application to enter the engine service, either as a new employee, or by transfer from some other department, the following additional test will be made. Place one pair of the test glasses in spectacle frames before the eyes of the applicant, and have him read another of the 20-foot cards, at 20 feet, then try the other pair of glasses. If he can read the letters through the plane glasses, but cannot read them through the convex, or magnifying, glasses, note on the form, under the head of Remarks, "test with test glasses satisfactory"; but if the letters can be read through both pairs of glasses, note "test with test glasses not satisfactory." Engineers and firemen in the service will be tested with the test glasses, and if they have 20/20 or 20/30 vision with *both* pairs of glasses they will be re-examined yearly for vision.

COLOR SENSE.—1. Holmgren Test. Place the whole number of colored worsteds on a table in good clear daylight, put the light green test skein A at a little distance from the other colors and ask the person being examined to select from the heap of colors all that look to him like the test skein, and place them beside it. Have him understand that he is not expected to find an exact match for the test skein, but that he is to choose all the colors that appear to him of the same general color as the test skein, both those that are lighter and those that are darker in shade. If he does not easily understand what is wanted, let the Examiner himself select the colors, then having returned them to the general heap and mixed them thoroughly with the rest of the colors, let him call on the person being examined to repeat the selection. This demonstration will not enable a person who is defective in his color perception to select the colors correctly, and he will pick out as looking to him like the green test skein A, some greens, and also some of the gray or brown confusion colors, which will appear to him of the same general color as the test skein, only varying from it in shade. Note on the form, the numbers on the tags of the colors selected as similar to the test skein A, and also note whether the selection is prompt or hesitating. Return all the colors to the heap and mix them together, then place the rose test skein B apart from the rest, and have the person being examined select as before all the colors that look to him like this skein, and note the numbers on the colors so chosen

No names should be mentioned in connection with any color in the above worsted tests; the tests should be based only on a comparison of colors.

2. Lantern Test. The room being darkened, light the test lantern and place it 20 feet from the person being examined about on a level with his head. Set the upper disc so that empty spaces come in front of the lights, the letters A and C being illuminated on the upper part of this disc. Push the brass buttons on the front of the lantern so that the ground glasses on the inside of the lantern are brought in front of the lights. Set the handle of the diaphragm at the lowest notch so that the colors are seen through the full-sized openings of the discs. Then turn the lower disc, carrying the colored glasses, which will show two colors at a time, and have the person being examined call the names of the colors as shown; for instance, "left, green; right, red," etc. Note on form T 523 the name given to each color as shown, corresponding to the number on the lower disc under the color.

Repeat the test, placing the handle of the diaphragm in the highest notch so as to have the color seen through the smallest opening, and turn the upper disc so that only the letter C is illuminated; in this way, only one color will be seen at a time. Turn the lower disc and note as before the names given to the colors as shown. In case there is any question as to the color perception of the person being examined, further tests may be made by combining the smoke glasses of the upper disc with the colored glasses of the lower disc and using either the largest or the medium-sized openings of the diaphragm; but the smallest openings of the diaphragm should not be used with the smoke glasses of the upper disc. Also, the ground glasses inside the lantern may be pushed aside to vary the test.

3. No person can be considered to have satisfactory color perception who calls a red light green, or a green light red, under any of the varying conditions of the lantern test; or, who selects the grays, browns, or reds with the greens, as looking like the green test skein, *and* selects any of the grays, blues, violets, or greens with the rose or red colors, as looking like the rose test skein of the worsted test.

HEARING TEST. Place the person to be examined at a distance of 20 feet, with one side toward the Examiner; have him stop the ear furthest from the Examiner by placing the finger over it, then let him repeat aloud the words or numbers spoken by the Examiner in a conversational tone, and note the distance in feet at which they can be repeated correctly. Have him turn the other ear toward the Examiner, and repeat the test.

With one ear closed as before, note the greatest distance in feet at which the ticks of the ratchet acoumeter can be counted correctly, with each ear. Hold the acoumeter by its narrow edge between the forefinger and thumb, not shielded by the fingers, and with one flat face directed toward the person being examined.

REMARKS.—Under the head of Remarks note any incident which might impair the accuracy of the tests, as escaping steam, etc , or anything which gives any additional information in regard to the tests.

RE-EXAMINATIONS.—All employees who are required to pass an examination for vision, color sense, or hearing, will be re-examined as follows: 1. At the end of three years from the date of the last examination; or, yearly (for vision) in Class A if one eye is found to have less than 20/40 of normal vision. 2. After any accident which might be caused by defective vision, color sense, or hearing. 3. After any serious accident, or after recovery from any severe illness, or after severe inflammation of the eyes or eyelids. 4. Before promotion. 5. Yearly, for vision, in case of enginemen and firemen who have 20/20 or 20/30 vision with *both* pairs of test glasses.

STANDARDS OF ACUTENESS OF VISION.—The following standards of acuteness of vision will be considered as satisfactory for the different classes mentioned. These standards must be strictly observed, but if in the opinion of the Division Superintendent any exception should be made, the matter must be referred to the General Superintendent for final decision, with full report containing the reasons therefor.

CLASS A.

	On Entering the Service, or Promotion.	Re-examination of those in the Service.
Enginemen. Firemen.	20/20 in each eye, tested separately, without glasses.	Not less than 20/30 with both eyes open, without glasses; each eye should also be tested separately and the vision of each noted.

CLASS B.

	On Entering the Service, or Promotion.	Re-examination of those in the Service.
Passenger Conductors. " Baggagemasters. " Brakemen. Ticket Collectors. Asst. Conductors. Freight Conductors. " Brakemen. Yard Masters. " Conductors. " Brakemen. " Enginemen (retired from road service). Switchmen. Draw Tenders.	20/20 in one eye and not less than 20/40 in the other, tested separately, without glasses.	Not less than 20/40 with both eyes open, without glasses; each eye should also be tested separately and the vision of each noted.
Towermen. Telegraph Operators. Station Agents. Section Foremen.	20/20 in one eye and not less than 20/40 in the other, tested separately, with or without glasses.	Not less than 20/40 with both eyes open, with or without glasses; each eye should also be tested separately and the vision of each noted.
Crossing Flagmen.	Not less than 20/40 with both eyes open, with or without glasses.	Not less than 20/50 with both eyes open, with or without glasses.

CERTIFICATES.—In case glasses are necessary to bring the acuteness of vision up to the above standards, the Examiner will report the facts to his General Superintendent, through the Division Superintendent, on form T 523, with the full record of the examination, and the certificate will be withheld until he receives the approval of the General Superintendent. This will not apply to Towermen, Telegraph Operators, Station Agents, Section Foremen, or Crossing Flagmen.

The Examiner will give a certificate, form 1523, to each person passing a satisfactory examination. This certificate will be dated and signed by the Examiner, and will also be signed in his presence by the person examined.

The above instructions will apply to all tests of vision, color perception and hearing, made after May 1st, 1901.

As soon as practicable all employees who are required to pass such tests, and who have not been examined by one of the Company's Examiners since April 1st, 1899, must be examined in accordance with the above instructions.

W. E. CHAMBERLAIN,
General Manager.

BOSTON, May 1st, 1901.

FORM 1523.

The New York, New Haven and Hartford Railroad Company.

This certifies that I have this day carefully tested the Acuteness of Vision and Color Perception of...................................... whose signature is attached hereto, and find that he is not disqualified by color blindness or other defective sight from employment where he is required to distinguish form and color of signals.

.... Examiner.

.... 1......

....
Signature of party examined.

Color Perception.

THE NEW YORK, NEW HAVEN AND HARTFORD RAILROAD COMPANY.

DIVISION.

Record of Examination of Sight, Color Sense, and Hearing.

NAME.	OCCUPATION.	DATE.

SIGHT.

Acuteness of Vision, without Glasses.	Right Eye.	Left Eye.	Both Eyes Open.	Reading Test, both Eyes Open,	Without Glasses.	With Glasses.
Distance in feet, at which standard test-type are read,				Size of reading test-type read correctly,		
Smallest line of standard test-type read correctly,				Written train orders read correctly (Yes or No).		

Position Signal Test, without glasses.	Right Eye.	Left Eye.	Both Eyes Open.
Distance in feet at which card with semaphore arms can be read correctly,			

COLOR SENSE.

Test-Skein Submitted.	Numbers on the Skeins in Standard Holmgren Color Set, selected as similar to Test-Skeins.
A Green.	
B Rose.	

Testing Lantern, two lights.	Size of Opening.	Number shown.	1	3	2	4	3	5	4	6	5	7	6	8	7	9
		Name given.														
		Number shown.	8	10	9	11	10	12	11	13	12	1	13	2	1	3
		Name given.														

Testing Lantern, one light.	Size of Opening.	Number shown.	1	2	3	4	5	6	7
		Name given.							
		Number shown.	8	9	10	11	12	13	1
		Name given.							

HEARING.

Number of feet at which numbers or words can be repeated correctly when spoken in a conversational tone.	Right Ear,	Left Ear,
Number of feet at which ratchet acoumeter can be heard.	Right Ear,	Left Ear,

REMARKS:

Examiner.

COLORADO.—The State of Colorado embraces about twice as much territory as the whole of New England. The western two-thirds of the State is covered by a portion of the Rocky Mountain system, while the eastern one-third consists of the western margin of the Great Plains which gradually ascends in height from 4,000 feet on the eastern border of the State to 6,000 feet where the foothills of the Rockies begin. The foothills with their adjoining valleys vary from 6,000 to 7,000 feet in elevation.

Westward of the foothills are the natural parks, standing at altitudes between 7,000 and 10,000 feet, interspersed among the mountains of which in Colorado there are 130 peaks ranging from 13,500 to 14,500 feet.

The eastern or plain portion of the State consists of elevated plateaux which are for the most part barren of trees and vegetation save for the native buffalo grass, and the streams are few and small. This region is uninhabited except in the few widely scattered ranches and small towns.

A few miles eastward from the foothills, along the margin of the plains where they approach the mountains, are situated the most prosperous and populous towns in Colorado, and it is on this strip of land that most of the invalids locate. In the northern portion of this area, on the plains some fifteen miles from the foothills, stands the city of Denver, the capital of the State, while seventy-five miles to the south of it, and only five miles from the mountains, is Colorado Springs with its suburbs. Forty miles to the south is the manufacturing city of Pueblo, and still farther, on the borders of New Mexico, is the city of Trinidad with its important coal mines.

To the westward, in the valleys among the foothills, are found the smaller towns of Boulder, Golden, Manitou, and Cañon City.

The mountain parks are used in the summer by invalids, some of them (especially Estes Park and Manitou Park) being well supplied with accommodations for visitors. On the western side of the Rockies are many prosperous towns, which are not as much used by invalids as those of the eastern slopes because of the climate being less dry. Glenwood Springs, however, is a place much frequented by the sick, though not usually by those who are tuberculous. The varied topography of the State naturally gives rise to variations in climate, though all share in the common attributes of sunniness, dryness, and diminished barometric pressure. In the eastern or plain portion is to be found the most sunshine and least humidity, but with more dust and wind than in the sheltered valleys and parks of the mountain regions. The average annual rainfall is fifteen inches. The range of the greatest annual extremes is not more than ten inches, while on the coast of California it extends to thirty-nine inches. The rain is naturally more copious on and near the mountain peaks, and at this great height it usually though not invariably increases with the altitude. On the eastern side of the main range the bulk of the precipitation occurs during the summer half of the year, there being no rain through the winter and very little snow. On the western, or Pacific slope, on the other hand, the precipitation during the winter six months is somewhat greater than in the summer. The mean relative humidity of Colorado is 50 per cent., and the actual humidity 2.04 grains per cubic foot of air, the average annual temperature being 50° F. This dryness of the air causes both the heat and the cold to be better borne for reasons which are so well explained by Professor Harrington in his paper upon sensible temperatures to be found in the transactions of the American Climatological Association (vol. x.).

"The sun in Colorado, in that great tract along and among the eastern foothills, in which are located Denver, Colorado Springs, Manitou, Pueblo, Trinidad, Golden, Boulder, Fort Collins, and Greely; in that region to which the tourist and the invalid are most likely to come, and in which they are likely to stay longest—the sun here shines for about sixty-two hours out of every hundred in which it is above the horizon. In Philadelphia the ratio is forty-nine. During the winter months, the trying time for the invalid, the difference is more striking still. In Colorado we have from December to March, 56 per cent. of all possible sunshine. In Philadelphia they get but 37 per cent.; a difference in Colorado's favor of over one-half. In ten years there were in Denver, on the average in each year, 314 clear or partly clear days. In Chicago, in the same period, there were only 251; in New York, 262. During the three winter months the sun shines four out of every five days. Nor do these figures tell the whole story. One of the greatest advantages of this eastern belt along the front of the range is the early morning sunshine. There are no high mountain ranges for the sun to climb, as in so many high altitude resorts in other lands, but its first rays above the low eastern horizon are at once warming and cheering. The sun is up before the invalid is awake, and the air is warmed for his outdoor life without a long wait till mid-morning. In Davos, Switzerland, the sun on January 1st does not rise till 10 A.M., and sets at three in the afternoon, a possible sunshine of only five hours. In Denver on January 1st the sun rises at 7:30 A.M. and does not set till after 4:30 P.M.: more than nine hours of sunshine.

"Neither do the few cloudy days preclude an outdoor life, as might be inferred. They do not bring the damp and rawness of the Eastern or Middle States. To many there is a restfulness in a clouded day from the constant intensity of clear blue sky." *

The temperature of the air in the sunlight and in the shade varies from 40° to 60° F. There is a large amount of electricity and marked diathermancy of the air.

The wind movement of Colorado is high, especially on the plains, though it is not as high as that of the most important cities of the Union.

Through the country, where the plains and mountains meet, the seasons may be thus briefly described: March is usually dry and a pleasant month with but few storms. April is, perhaps, the most disagreeable month of the year, as in the first half wet snow storms or heavy rains are usual. In May the weather improves, and in the last half of the month it is generally good. June is dry and warm. Through July and August the summer heat is not excessive, the mornings and evenings being bright and beautiful, while in the afternoons heavy thunder showers lasting some twenty minutes are usual. By the middle of September the rains have ceased, and beautiful, dry, sunny autumn weather is experienced usually until the turn of the year. In January and February the coldest weather occurs, but as it is dry, clear, and sunny it is bracing and pleasant, except to those who are too feeble to react to its tonic effects.

Dr. C. T. Williams, in describing the quality and effect of the various factors of the Colorado climate, writes as follows: "Thus the climate of Colorado is dry and sunny, with bracing and energizing qualities, permitting outdoor exercise every day all the year round, the favorable results of which may be seen in the large number of former consumptives whom it has rescued from the life of invalidism and converted into healthy, active workers." †

Boulder—elevation 5,300 feet, population 5,000, latitude 40°. This little town is situated at the mouth of Boulder cañon, some thirty miles northwest from Denver. The State University of Colorado is here, and there is also a sanitarium which is a branch of the Battle Creek sanitarium. Comfortable accommodations can be obtained at the hotel and boarding-houses. The mean temperatures (Fahr.) as recorded are: spring, 49°; summer, 65°; autumn, 49°; winter, 24°. Total rainfall, 19.21 in.; spring, 8 in.; summer, 7.7 in.; autumn, 2 in.; winter, 1.51 in. The humidity and wind movement observations are not to be obtained. The soil is sandy. The water supply is good, but there is no system of sewerage.

Cañon City—elevation 5,300, latitude 38° 30′; population 4,500. Cañon City lies in a valley close to the entrance to the Grand Cañon of the Arkansas. It is forty-five miles northwest of Pueblo. It is well sheltered from winds, except where an occasional westerly wind blows through the cañon. It has a mild winter climate. The soil is mostly adobe, so it is slow in drying up after rain and snow. The water supply is good. There are fair hotels and boarding-houses, and the prices are moderate. The streets are pleasantly shaded with trees. Fruit growing is successfully carried on by irrigation throughout the valley. There are hot and cold soda springs. The seasonal temperatures (Fahr.) and rainfall are as follows: Spring temperature 52°, rainfall 4.2 in.; summer temperature 72°, rainfall 4.2 in.; autumn temperature 53°, rainfall 1.6 in.; winter temperature 34°, rainfall 1.8 in.

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* Colorado: "About its Climate." By J. C. Dana, Librarian, and Carroll E. Edson, M.D., Denver, Col.

† "Aerotherapeutics," by Charles Theodore Williams, M.D., London.

Colorado Springs—elevation 6,000 feet: latitude 38° 51′; population 30,000. Colorado Springs is situated seventy five miles south of Denver on the mountain shore fringing the ocean of the Great Plains. "These plains, which begin to rise eight hundred miles away to the eastward and stretch an equal distance north and south, have been called the Great American Desert. This great plateau is almost completely barren of trees and crops, and is traversed by a few slender streams. The arid soil yields but little water from infrequent wells and springs, and the dry air blowing over this plateau gives but scant moisture; so that there are only a few scattered oases of cultivation in this vast expanse of grassy plain. To the eye the rolling prairie conveys the impression of the sea, and, no doubt, it was this thought that prompted the early pioneers to call their wagons as they slowly lumbered over the plain 'prairie schooners,' the wagon covers in the distance resembling sails.

"The town has in the west, towering eight thousand feet above it, that great sentinel of the Rockies, Pike's Peak, with its shoulders sloping to the lower heights of Cheyenne Mountain in the south and melting into the Front Range in the north, with a spur, the Divide. This Divide projects from the front range to the eastward, with its crest being twenty-five miles north of the town, and curving southward; it therefore shelters the city on the north and east. These mountains and their spurs form a semicircle. The town situated in the depth of the curve lies, as it were, in a bay opening southward to the ocean plain." *

In looking landward from the town it will be noticed how it is encircled by ramparts formed by the ground rising from 6,500 feet on the east up to 7,000 feet on the north, and sloping upward along the western line to over 14,000 feet upon the summit of the Peak and southward again to the 6,500 foot level. The ramparts formed by the mountains afford shelter from the sweep of the continental storms and by their attraction keep back much of the rain and snow that gather around the Peak. The lofty eminence of this grand mountain, piercing the upper cooler strata of the atmosphere, draws toward it the clouds which, as they break, pass southward over Cheyenne Mountain and northward over the Front Range, and thus eastward along the ridge of the Divide.

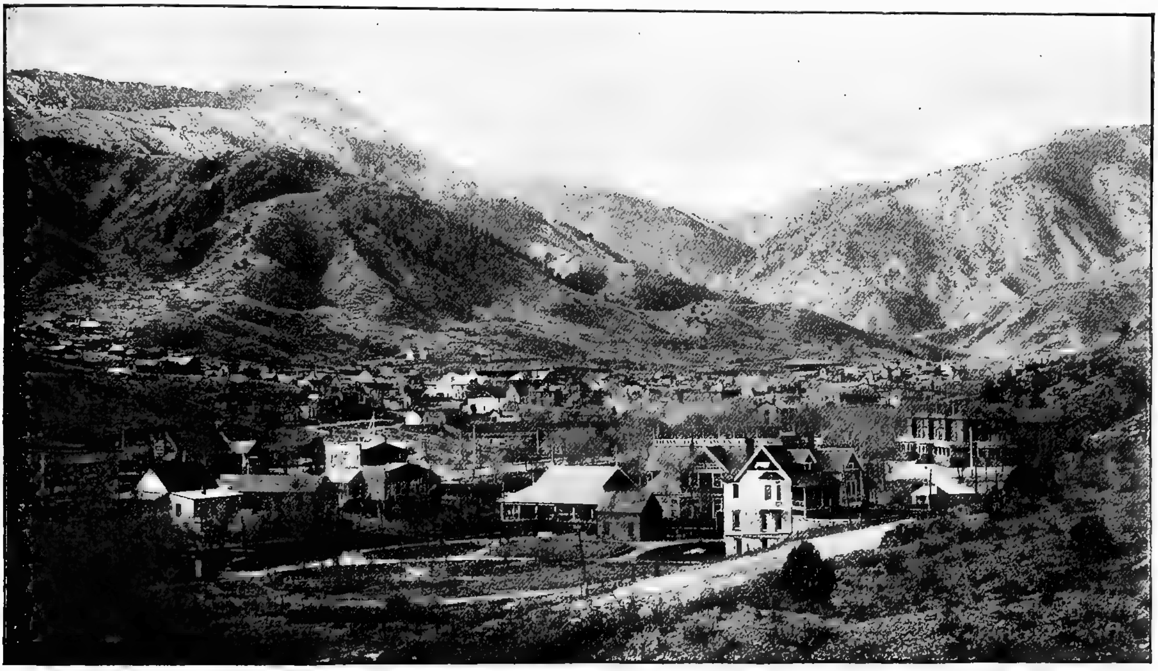

Fig. 1470.—Manitou, Colorado, on the Denver and Rio Grande Railroad.

The heavy trans-continental storms coming from the west over the mountains, for the most part, do not strike the plains short of fifteen miles to the eastward, because of the great width of the angle at which they descend by reason of their great velocity and the height of the mountains they have to cross, thus leaving the town in the wind-shed below. This sheltered position does not, however, prevent the town from experiencing on these occasions much movement of the air from the eddying currents set in motion by the storms that pass over and around it.

Perhaps one of the strongest features in the resemblance to a seashore is in the customary daily variations of the local winds. Wherever the land and ocean meet there is a daily breeze blowing from the sea to the land and a nightly one from the land to the sea. Here we have in the diurnal winds an exact counterpart of the sea and land breezes. In ordinary weather, throughout the night, a gentle breeze blows from the north and northwest, and as the sun begins to rise the wind shifts eastward and, passing south, blows from the southwest during the early afternoon; then turning backward through the eastern quarter it reaches the north once more as the sun goes down, where it lingers through the night. The velocity of the

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* "An Inland Seashore," by S. E. Solly, M.D., Mountain Sunshine, Fall Number, vol. i., 1899, p. 2, Colorado Springs.

wind is very slight during the hours of darkness, but increases after daybreak up to two or three o'clock in the afternoon when it blows with its maximum force, gradually dying down again as sunset approaches and it returns to the northern quarter. Thus we have by day a sea or plain breeze, by night a shore or mountain breeze.

The customary winds are, however, very different in their quality from those on the seashore, because they are dry instead of moist. This is particularly the case in contrasting the sea and plain winds. The winds passing over the ocean toward the shore must, from the very nature of things, bring with them much humidity, so that in whatever climate a sea breeze blows it is always damp and there can be only relative dryness in sea breezes, but owing to the varying temperatures its effects may be very different. For instance, on a seashore where there are brilliant sunlight and genial warmth, as on the coast of Southern California, through the warmer hours of the day the sea breeze blows and does not part with its humidity as rain or fog. During the early morning and evening hours the change of temperature is usually too slight to cause a fall of rain, but the moisture in the air condenses to a light fog. This condition is practically the same both summer and winter in California, but on the North Atlantic coast the conditions are only similar during the summer, while in winter the greater cold brings harsh weather with increased precipitation. The great and important difference between this fancied seashore and a real one is that it is dry instead of moist, though they are alike in this, that breezes bring an abundance of pure air which has blown over surfaces untainted by malaria or the habitations of man. It is the proximity of the great plains with their dry, treeless, and sparsely populated soil that gives to Colorado Springs such a magnificent reservoir of pure, sun-dried air for it to draw upon.

The open aspect to the south and east with the sloping southern shoulder of the Peak, allows longer hours of sunshine and intenser light than are found in the Swiss mountain valley resorts. For instance, on the first day of January the possible hours of sunlight in Davos are four hours, whereas in Colorado Springs they are nine.

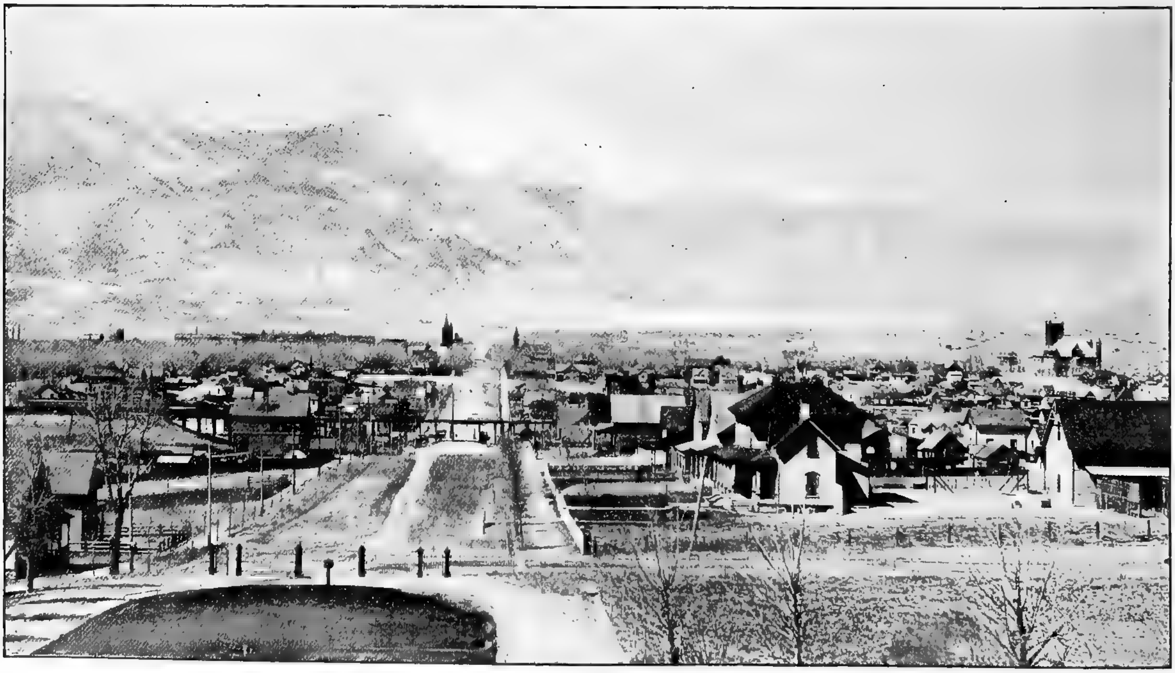

FIG. 1471.—Colorado Springs, on the Rio Grande Railroad, with Pike's Peak in the Distance.

In the Alpine valley resorts the daily breeze blows more gently over chilly mountain tops or ice fields, bringing a much cooler and slightly damper atmosphere than that which reaches Colorado Springs from the plains. While the qualities of the Colorado Springs diurnal winds are suited and agreeable to many, yet for others the greater coolness and lesser velocity of the daily breeze experienced in Davos are more to be preferred.

The plateau upon which the town stands is composed of sand and gravel, rising some seventy feet above the clay bed of the streams. In this soil no water is to be found and the city is dependent upon water brought from the mountains. The surface of the plateau thus lifted above the river valleys is level and has a gentle slope from north to south, which allows good natural drainage and easy sewerage. When one is standing on the town site, the elevation of this plateau above its immediate surroundings conveys the impression of height; but on looking down upon the town from the encircling benches or hills, we then see that it really rests in the hollow of a bay with two sheltering arms stretching out from Pike's Peak around it to the north and east, and to the south and west, leaving the southeastern aspect open to the plains.

Occasionally during the winter half of the year the wind will remain throughout the day in the northern quarter, bringing cold, stormy weather from across the mountains; though when the thermometer drops near or below zero, as it occasionally does, the wind usually also abates, so that the intense cold is quite endurable and even pleasant if the body is well protected by warm clothing. It is also a rare day when the sun does not shine. During the nights, which are usually the coldest portion of the twenty-four hours, there is rarely much wind blowing. After a cold snap, when snow has fallen, often the chinook—a warm, dry wind which rapidly melts the snow and dries the ground—will blow from the west. It is similar to the föhn wind of Switzerland, which is sometimes called "the snow eater." The velocity of the chinook is very great, but it rarely blows more than a few hours at a time. Winds from the west and southwest are infrequent, but in addition to those which have been mentioned occasional local breezes will spring up, blowing from the west, but not of high velocity or of long duration.

The mean total monthly wind movement is at Colorado Springs, 6,663 miles; New York, 6,883; Boston, 7,997; Chicago, 7,007; St. Louis, 7,011; San Francisco, 6,863. These places all show a greater amount of wind movement than Colorado Springs, while, on the other hand, in the following places the wind movement is somewhat less: At St. Paul it is 5,156 miles; San Antonio, 5,301; San Diego, 4,105; Thomasville, 4,225; Denver, 4,980, and Pueblo, 5,438. This average annual monthly movement of the wind at Colorado Springs is largely augmented by the spring gales, the autumn and early winter being much less windy.

The hourly wind velocity at Colorado Springs during the autumn is nine miles per hour, being only slightly greater than that of the summer season, and quite a little less than that of the winter and spring.

The number of cloudy days of the entire year is very small, averaging but 57 as against 129 in the Adirondacks, 106 at Asheville, 97 at Thomasville, 92 at San Antonio, and 73 at Santa Barbara. In the principal cities of the Union—Boston, New York, Chicago, St. Louis, and San Francisco—the number of cloudy days range from 88 at San Francisco to 117 at Chicago. Of the 57 cloudy days which occur through the year at Colorado Springs the fewest are seen during the autumn, averaging less than half the number in the summer and winter and one-third of the number during the spring, which is the cloudiest season.

The annual average rain and melted snow fall is 14.5 inches, as contrasted with 39 in the Adirondacks, 45 at Asheville, 48 at Aiken, 51 at Thomasville, 30.5 at San Antonio, and 18 at Santa Barbara. In autumn the precipitation is not more than two inches.

The annual average relative humidity of Colorado Springs is 50 per cent., being 19 per cent. less than Asheville, 15 per cent. less than Thomasville, 18 per cent. less than San Antonio, and 23 three per cent. less than Santa Barbara. In the autumn it is about 4 per cent. higher than in the winter and summer, and 8 per cent. higher than during the spring. This is because of the diminished precipitation; a little more moisture being retained in the air.

The annual average absolute humidity of Colorado Springs is 1.48 grains as against 3.24 grains for Asheville, or 4.86 for Thomasville, or 5.26 for San Antonio and 4.20 for Santa Barbara. In the autumn the absolute humidity in Colorado Springs is 2.05, which is very low, though slightly in excess of the annual average.

The average temperature (Fahr.) for autumn of Colorado Springs is 48°, contrasted with 43° in the Adirondacks, 53° at Asheville, and 61° at Aiken, 62° at Santa Barbara, and 34° at Davos-Platz.

The average night temperature of Colorado Springs for the autumn is 34°, being about the same as that of the spring; while in summer it rises to 51° and in winter drops to 17° F., owing to the cold but still night.

Colorado Springs has a complete system of sewerage, electric lights, and electric street cars. The water supply is brought in pipes from the mountains and is abundant and pure. The wide, level streets are shaded by trees. There are excellent stores, four banks, two theatres, and several first-class hotels. The Antlers, recently rebuilt,

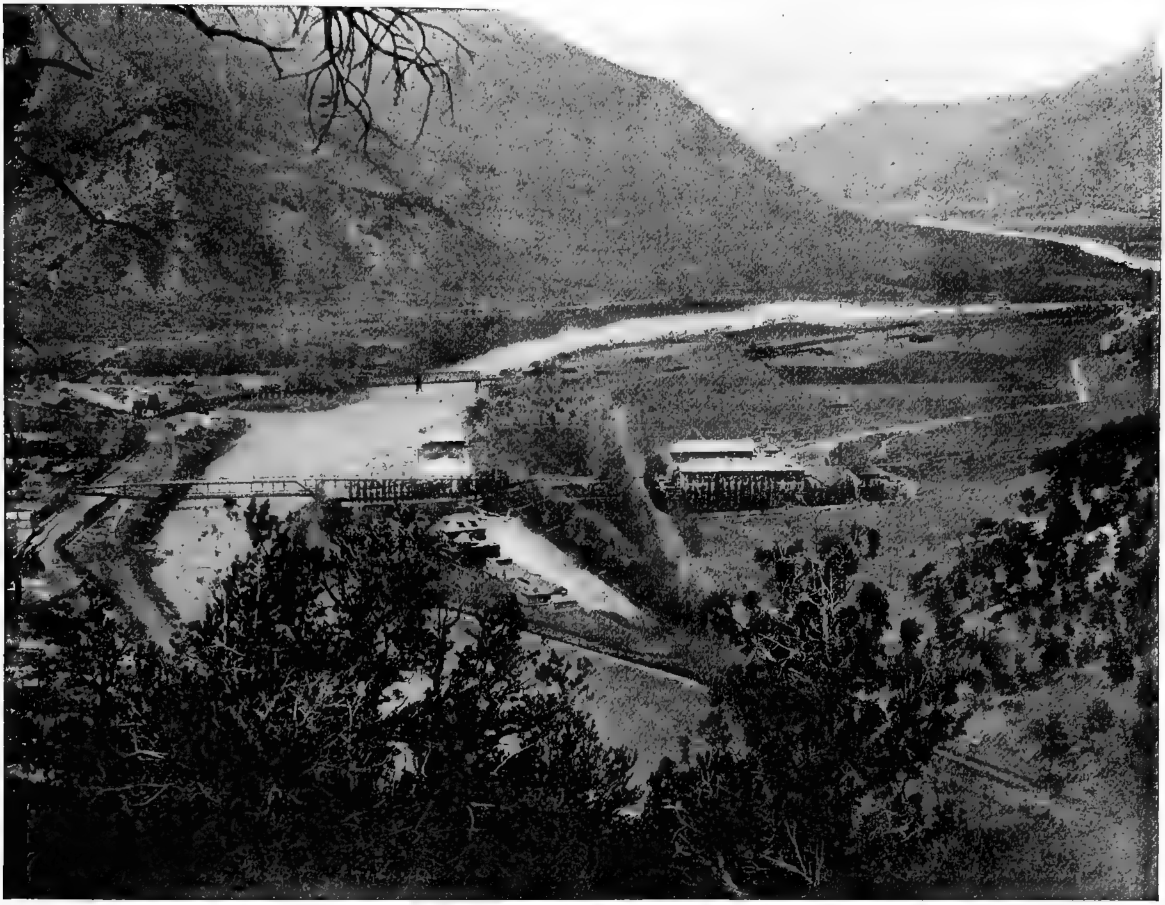

FIG. 1472.—Glenwood Springs, Colorado, on the Western Slope of the Rocky Mountains. Elevation, 5,200 feet. View of hotel, bath-houses, and pool.

is the most complete hotel in the West; it is fireproof and stands in a beautiful park. A fine social club house and two country clubs are adjacent. The churches are numerous and well served. The residences are detached, with gardens and trees around them, and are for the most part pleasing in their architecture. The general air and resources of the city suggest the best type of the Eastern rather than that of the Western States.

Glenwood Springs—elevation 5,200, population 1,500—lies on the western slope of the great continental Divide, and is situated in a valley at the junction of the Grand and Roaring Fork rivers. The Denver and Rio Grande and the Colorado Midland railways pass through the town on their way from Denver to Salt Lake and the Pacific coast. Here is the far-famed Yampa hot spring, from which flows each minute 2,000 gallons of water at a temperature of 134° F. This water is rich in salts, and sulphureted hydrogen gas is freely given off from its surface. The arrangements for bathing are of the most complete and modern description. There is an open swimming pool 700 feet in length and 100 feet in width, in which a hot salt bath can be thoroughly enjoyed. On one side of this pool is a beautiful bathhouse containing baths of all kinds; on the other are sulphurous vapor caves which are most comfortably fitted up. The baths of Glenwood are justly celebrated for their efficacy in the treatment of various diseases, especially gout, rheumatism, syphilis, and certain renal and hepatic affections. Its climate is soothing and restful and of great service in irritable nervous disorders.

"Glenwood Springs has one of the finest hotels in the West. It is a large building in the Italian style of architecture, constructed of Colorado peachblow-colored stone and Roman brick. It surrounds an open court which is terraced, and has grass plats, fountains, and beds of flowers. The hotel has 200 guest rooms; it is well heated, liberally supplied with open fireplaces, and is lighted by electricity."*

Climatic Conditions at Glenwood Springs.

Monthly mean temperature (Fahr.)	
Winter	27°
Spring	50
Summer	69
Autumn	47
Year	48
Rainfall (total, inches)	
Winter	4.90
Spring	3.04
Summer	3.80
Autumn	4.22
Year	15.96
Monthly mean temperature for January (two years)	22°
Monthly mean temperature for July (two years)	72°
Mean yearly minimum (three years)	5°
Mean yearly maximum (three years)	100°

Therapeutic Use of Colorado.—What has been written about the use of high stations in the Alps applies to Colorado with certain modifications. The latitude of Colorado is much lower than that of the Alps, that of Colorado Springs being about the same as that of Naples. It is therefore much warmer, and also, because of its situation in the interior of the continent, much dryer; moreover, it enjoys the climate of the high plateau as well as that of the mountain. This increases the dryness, the length of sunshine, and also the windiness of the climate. If the reader will turn to the description of Colorado Springs, he will understand how this health station combines the features of a plateau and a mountain station in a remarkable degree. The other places mentioned in this article, except Denver and Pueblo, lie more in the mountains, and receive more shelter but less sunshine, and are less under the influence of the air of the plains. When Colorado was first visited as a health resort, the idea was that it was better to place stations, particularly for consumptives, in the more sheltered resorts. For instance, Manitou and Cañon City were greatly used, and Colorado Springs very little; but the experience of the patients and of the doctors brought about a change in this respect, and, in spite of the accommodations being inferior at that time, patients frequented Colorado Springs in large numbers to the neglect of the sheltered resorts. At the present time, and indeed for some years past, the accommodations and resources for invalids have been excellent at Colorado Springs, and far better than in any other resort in the Rocky Mountain region. The wisdom of this change of base has been proved by the local experience, and is further corroborated by the successful use of open-air treatment in England and elsewhere, where the exposure to wind and stormy weather is much greater than in Colorado Springs. At the same time, the more sheltered spots are of greater service to a few of the cases. While, in comparing Colorado Springs with the Alpine resorts, we find that it excels them in the amount of sunshine and dryness, and because the climate is less harsh, we must at the same time admit that it falls behind them in that there is more wind and dust. One of the most prominent advantages that Colorado Springs enjoys—an advantage which is also shared in a lesser degree by the other Colorado resorts—is that the consumptive patient can continue under the influence of the climate all the year round, there being no falling and melting snow periods as in the Alps. To this the writer attaches great importance, because he does not believe that in seriously affected cases a residence of a few months is sufficient to insure permanent results. Further, when the consumptive is able to move about and take exercise, he has a wide area over which he can pass; he can ride and drive, play golf, and vary his amusements. Also, at Colorado Springs, at least, he can have the advantage of literary and musical circles, and all kinds of educational and religious institutions, and find reasonable social distractions. Those also in whom the disease is arrested, but for whom it is inexpedient that they should return to their former home, or who do not desire to do so, can find opportunities for work or investment of money. The recent discoveries of gold at Cripple Creek have added to the wealth and prosperity of the city, and to the business opportunities of all kinds, but have not brought any of the objectionable features of the mining camp. Besides the resources of the town, there are beautiful environs in which patients can live or to which they can resort by day.

It is often urged that for a consumptive who, of necessity or by choice, returns to his home, it is far better that he be treated in the same climate. There are undoubtedly many cases, particularly those in an early stage, in which this can be done, or must be tried; but the objection which is often made, viz., that the patient in whom the disease is arrested in a different climate, especially that of an altitude, is unable to return with safety to his home climate, does not hold. The writer in his visits to England and the Atlantic seaboard of America frequently has the pleasure of meeting old patients who have recovered in Colorado, and who are continuing in good health in their former homes. It is chiefly a question of care, especially in the first months of their return, during the period of re-acclimatization. As Sir Herman Weber and other writers of eminence have said, a patient cured in a high altitude is just as much cured as one cured elsewhere, and if a patient's condition is such as to justify his return home, provided he has acquired the hygienic education that he should receive from his physician, he can do so without fear. Of course, in sending a patient far from home, his pecuniary, domestic, and social circumstances have to be very carefully investigated and considered before such a step is taken. Nostalgia is the curse of many patients, though it is surprisingly less under the sunny and stimulating influence of a high altitude than in resorts where cloudy weather and sedative influences dominate.

The journey to Colorado, owing to the distance, is usually expensive, and the cost of living ranges about twenty-five per cent. higher than in most of the cities at sea level, but is very little if any greater than in the generality of health-resorts. Fair accommodations can be secured at a dollar a day, but for the well-to-do they would range from one and one-half to two and one-half per day. This applies to boarding-houses, which are both numerous and of all qualities. The best hotels charge from three to five dollars a day, somewhat lower rates being secured by the week.

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* Solly's Handbook on "Climatology," p. 251.

The writer believes, and statistics confirm the belief, that in properly selected cases the arrest which is brought about in an altitude is more rapid and more lasting than that which has been procured in low places, this being probably mainly due to the fact that the changes in the blood quickly remove the anæmia. Open-air life is possible and agreeable for the whole twenty-four hours throughout the year, except during occasionally stormy spells, many patients sleeping out upon balconies through all the seasons. The statement is undoubtedly true that for most consumptives cold is better than heat; therefore the majority of consumptives improve more in the cool air of Colorado than in the warm air of New Mexico and Arizona. However, fibroid patients, in whom the circulation is feeble, and catarrhal individuals, to whom the variations of weather are dangerous, improve more surely during the winter in the warmer climates of New Mexico and Arizona, although in the summer time the cool, temperate weather of Colorado suits them better than the extreme heat of Arizona and New Mexico. If the reader has studied the meteorology of this region, and has read the article upon *Altitude*, he will appreciate the indications for selecting Colorado Springs or the other resorts which have been described, and also will appreciate the principles upon which the choice of an altitude should be made. *S. Edwin Solly.*

COLORING MATTERS, ANIMAL.—Many of the animal coloring matters are substances of considerable functional consequence. Some, for example, are of special service in respiration; others appear to be important factors in vision; a large number afford protective effects; several, also, are attractive in their influence. A majority, however, seem to be without any apparent physiological relations and not a few are purely excretory products.

I. CLASSIFICATION.

The multitude of animal pigments may be arranged conveniently in the following general groups:

1. RESPIRATORY PIGMENTS.—These coloring matters are very important functionally. Most of them are carriers of oxygen, with which they unite loosely, receiving it in the organs of respiration, conveying it to the body parts, and there giving it up to the tissues. The leading ones are compound ("chromo") proteids. Among them are hæmoglobin, hæmocyanin, hæmerythrin, and chlorocruorin.

2. DERIVATIVES OF RESPIRATORY PIGMENTS.—Some of the best-known animal coloring matters are derivatives of hæmoglobin, and many of the colored substances in the lower animals are undoubtedly formed from their blood pigments. Prominent derivatives of hæmoglobin are bilirubin (hæmatoidin), stercobilin (urobilin), urochrom, and hæmatoporphyrin.

3. LIPOCHROMES.—These substances, yellow or yellowish red for the most part, are very numerous. They are found particularly in adipose tissue, yolk of egg, butter, and in the tissues and epidermal structures of the lower animals. In solubilities they are much like the fats, and they show absorption bands toward the violet end of the spectrum. Little is known of their chemical composition. They appear to consist of only carbon, hydrogen, and oxygen. Among them are serum lutein, tetron erythrin, and the "chromophanes."

4. MELANINS.—These are brownish-black pigments occurring especially in epidermal structures. They consist of carbon, hydrogen, nitrogen, and oxygen. Nearly all contain sulphur; a few, iron. It is thought by some that they are derivatives of hæmoglobin; by others, modified lipochromes. They have been produced outside of the body from simple proteids by prolonged hydration ("melanoidins"), which fact suggests, of course, that they may be so derived within the system. Among the typical members of the group are fuscin, phymatorhusin, and sepic acid.

5. CHROMOGENS.—These are the colorless, or less colored, precursors of actual pigments occurring in nature. The leading ones are indoxyl compounds, which give rise to red and blue indigo; melanogen; urorosein-ogen; the chromogen of the suprarenal medulla, related probably to the pigment of the skin in Addison's disease; and urobilinogen. The so-called "humous substances," obtained by destructive chemical methods, and such bodies as proteinochromogen (tryptophan), which merely form colored combinations with various reagents, are, of course, purposely excluded here.

6. MISCELLANEOUS PIGMENTS.—This residual group includes a very large number of protective, attractive, and other coloring matters, characteristic especially of the lower animals, studied only spectroscopically for the most part. Among those whose chemical individuality is not disputed are turacin, carminic acid, punicin, chlorophyll, and lepidotic acid.

II. DISTRIBUTION.

LOWER ANIMALS.—Coloring matters are widely distributed throughout the whole of the animal kingdom. In some animals they occur only in the body fluids, in others they are also diffused throughout various tissues. In many they occur in the form of granules in certain cells or cellular layers. Many of the lowest types, such as infusoria, sponges, and hydroids, contain *chlorophyll* (green) in granular form and some ciliated animalcules are colored by *stentorin* (blue). Chlorophyll is found in several mollusks, crustacea, and insects, and also in the so-called livers of many invertebrates (*enterochlorophyll*). The latter organs also contain a ferruginous pigment, *ferrin* (brown) and *cholechrom* or *hepatochrom* (reddish yellow), a lipochrom; also *helicorubin* (orange red). *Hæmatoporphyrin* (purplish red), a derivative of *hæmoglobin* (red), occurs in the integument of star fishes, slugs, the common earthworm, and various sponges. A number of corals and hydroids, and some sea anemones, are colored by *actiniochrom* (red); also by *polyperythrin* (red), probably identical with hæmatoporphyrin. Some actiniæ contain a coloring matter very similar to another derivative of hæmoglobin, *hæmochromogen* (red), and convertible into hæmatoporphyrin. Many echinoderms contain *pentacrinin* (red and purple) and the following pigments give special coloration to the lower species from which the terms are derived: *aplysiopurpurin* (purple), *bonellein* (green), *echinastrin* (red), *astroidin* (yellow), *rhizostomin* (violet), *ophiurin* (yellowish brown), *asterocyanin* (bluish violet) and *comatulin* (red). *Punicin* (purple) is derived from the colorless secretions of various mollusks on exposure to light, and *carminic acid* (red) is the pigment characteristic of the cochineal.

The shells of some mollusks, and also some corals, contain "lipochromoids" and "melanoids." The brownish-black ink of Sepia officinalis, used to color the sea water and cover the flight of the animal, contains a melanin, *sepic acid* (black). The green (*chlorophan*), yellow (*xanthophan*), and red (*rhodophan*) pigments, "chromophanes," of the oil droplets in the retinal cones of birds, reptiles, and fishes, as well as the yellow substance in the yolk of egg (*ontochrin*), are lipochromes. The egg of the water spider is colored by the two lipochromes, *vitellorubin* (red) and *vitellolutein* (yellow). Some of the characteristic coloring matters in decapod crustacea are lipochromes. The red *crustaceorubin* is closely related to hepatochrom (cholechrom) in the livers of these animals. The eggs of the river crab and the lobster contain the same bluish pigment as that in the carapace of the animals. This pigment, called *cyanocrystallin*, becomes red with acid and on boiling in water. Crustaceorubin appears to be derived from it. The shells of various birds' eggs are pigmented by hæmoglobin derivatives, among which are *biliverdin* (green); *oocyanin* (blue), closely related to biliverdin; *oorhodein* (reddish brown), probably identical with hæmatoporphyrin; *oochlorin* (yellow) and *ooxanthin* (red).

In certain butterflies the white pigment of the wings consists of *uric acid;* the yellow pigment, of *lepidotic acid,* which yields uric acid on hydration. The red pigment of the body scales is closely related to lepidotic acid. The wing covers of beetles contain *coleopterin* (red). The showy colors in the plumage of birds are due in part to the influence on light which the feathers themselves exert, causing the so-called "interference colors"; in great part, however, to pigments. *Turacin* (red) is one of the best known of these. Among the many other feather pigments are *turacoverdin* (green), *zoonerythrin* (red), *zoorubin* (brown), *zoofulvin* (yellow), *picofulvin* (yellow), *turacobrunin* (brown), and *psittacofulvin* (yellow). Nearly all of these, "lipochromoids" and "melanoids," seem to be very closely related to the numerous skin pigments in birds, and scale and flesh pigments in fishes, such as *tetronerythrin* (red) and *coriosulfurin* (yellow); and to *lacertofulvin* (yellow), *lipochrin* (yellowish green) and others, in the skin of reptiles and various amphibia. The red pigment, *diemyctylin,* of Diemyctylus viridescens, like lepidotic acid, yields uric acid on hydration. Many invertebrates contain "histohæmatins," hæmoglobin derivatives, chief of which is *myohæmatin* (*myochrom*) of the red muscles; found in the muscles of insects and mollusks, also, whose hæmolymph does not contain hæmoglobin. The characteristic color of the muscles of the salmon and other related fishes seems to be due to a red lipochrom identical with tetronerythrin. The nerves, particularly the ganglia, of some worms are colored bright red by hæmoglobin.

Hæmoglobin is present in the circulating fluid of many species of the invertebrate sub-kingdoms. It has been found in several species of the star fish family; in no lower invertebrate forms, however, but in most species of all genera higher up the scale. The corpuscles in the hydrolymph of sea urchins contain *echinochrom* (yellow), a "lipochromoid," with possibly respiratory function. The hæmolymph of various invertebrates is colored yellowish to yellowish green by lipochromes; violet to purplish red by "floridins," of which *hæmerythrin* (red) is the best known. Hæmerythrin, and also *chlorocruorin* (green), replace hæmoglobin in the hæmolymph of worms; *hæmocyanin* (blue) in that of most mollusks, crustacea, and some members of the spider family. In the hæmolymph of crustacea the lipochrom, tetronerythrin (crustaceorubin, zoonerythrin), is also frequently found along with the hæmocyanin. The blood of the common house fly, and other like species, contains hæmoglobin, but that of butterflies and many related insects is green, and contains chlorophyll derived from the food; although chlorophyll occurs in other parts as well. The blood of many insects turns brown to black when it is shed, to which process the term "melanosis" has been applied.

Higher Animals.—The various tissues and fluids of the higher animals owe their color, very often, to mixtures of several pigments. Colored granules are frequently derived directly from external sources; into the lungs (pneumonokoniosis), such as coal dust (anthracosis), iron particles (siderosis), etc., whence they are sometimes distributed to the liver, lymphatic glands, kidneys, and other organs. They result, also, from medicinal introduction, as reduced silver in the alimentary tract, skin, liver, kidneys, etc. (argyria.) Through the skin, also (tattoo). The following concise arrangement gives practically all the more important pigments found in man and mammalia generally, and will aid to reference to more extended accounts than can be given here. The terms in italics indicate the pigments occurring only under unusual or abnormal conditions:

Adipose tissue—lipochrom. Bile—bilirubin, biliverdin; also biliprasin and urobilin in some; *bilifuscin, cholohæmatin* (from chromogen), *hydrobilirubin, hæmoglobin, methæmoglobin, hæmatin.* Biliary calculi—bilirubin, biliverdin, bilicyanin, bilifuscin, bilihumin (?), biliprasin, choletelin (hydrobilirubin?). Blood—(*a*) corpuscles: oxyhæmoglobin, hæmoglobin; (*b*) plasma: serum lutein, bilirubin (in some); *hæmoglobin and direct derivatives, hæmoglobin compounds with poisonous substances, hepatogenous pigments, melanin.* Blood clots (old)—hæmatoidin (bilirubin), rubigin or hæmosiderin (ferric hydroxide). Bone—lipochrom in ossein and yellow marrow; red marrow: hæmoglobin. Conjunctiva—*bile pigments.* Connective tissues—lipochrom, melanin; *bile pigments.* Contusion—bile pigments, hæmatoidin. Corpus luteum—lutein, *hæmatoidin* (?) Cysts—lipochrom; hæmoglobin derivatives, including bile pigments. Eye—(*a*) choroid and iris, fuscin; (*b*) retina, 1. *rods*—visual purple (rhodopsin), visual yellow (xanthopsin); 2. *Pigment layer*—fuscin, lipochrin. Fæces—stercobilin (urobilin), indigo chromogens, urobilinogen; pigments from food, such as carrotin, chlorophyll, hæmatin; *hæmoglobin* and *siderous hæmatogenous pigments, bile* and *drug pigments.* Freckles—hæmatogenous pigment. Ganglion-cells—lipochrom. Gastro-intestinal mucosa—*hæmoglobin* and its *direct derivatives* (hæmatochromatosis). Glands in general—hæmoglobin in capillaries, chromogens, *hæmatogenous pigments.* Hair—lipochrom, melanin. Intestine—(*a*) concretions: hepatogenous pigment; (*b*) contents: essentially same as fæces, including bile pigment and hydrobilirubin normally. Leucocytes (phagocytic cells)—*any pigment* found elsewhere in the body. Liver—ferrin, cholechrom, *rubigin, non-siderous hæmatogenous* and also *bile pigments.* Lungs—*Inhaled particles, hæmosiderin, melanin* (?). Lymphatic (*a*) fluids—serum lutein, *hæmatogenous* and *hepatogenous pigments;* (*b*) glands: *hæmoglobin derivatives.* Meconium—bile pigments, *hæmoglobin* and its *derivatives.* Menstrual fluid—hæmoglobin and direct derivatives. Milk (cream, butter, cheese)—lipochrom; "blue milk," *triphenylrosanilin* (*B. cyanogenous*); "red milk," *pigment* by *M. prodigiosus.* Mole (nævus)—hæmatogenous pigment. Muscle—myochrom (diffused hæmoglobin?), myohæmatin (hæmochromogen?). Pancreas—hæmatogenous pigment. Placenta—hæmoglobin, hæmatoidin, hæmatochlorin (biliverdin?). Pus—lipochrom, pyocyanin (*B. pyocyaneus*), pyoxanthose, bilirubin, indigo blue (?), hæmoglobin and decomposition products. Sebaceous secretions—lipochrom. Skin—melanin, *bile pigments* (hæmochromatosis), *histohæmatins* (?). Spleen—hæmoglobin, *rubigin, non-siderous hæmatogenous pigment.* Sputum—*blood, bile,* and *pus pigments;* also inhaled particles. Stomach contents—food pigments; *blood and bile coloring matters.* Suprarenals—hæmochromogen and chromogen yielding red pigment on exposure to light. Sweat—*pyocyanin, indigo blue* (?), *bile pigments; hæmoglobin and derivatives* ("red sweat"); hippopotamus and kangaroo, reddish-brown pigment; dwarf antelope, blue. Tissues generally—coloration effects due to blood in capillaries; *bile pigments, hæmoglobin and hæmatogenous pigments.* Tumors—phymatorhusin, sarcomelanin, lipochrom, hæmoglobin and derivatives; horse: hippomelanin. Urine—(*a*) pigments: urochrom, urobilin, uroerythrin, hæmatoporphryrin (urospectrin), *skatoxyl red, melanin, indigo* (blue and red), *bile pigments, hæmoglobin and direct derivatives, drug coloring matters;* (*b*) chromogens: indoxyl and skatoxyl compounds; precursors of hæmatoporphyrin and urorosein (urorhodin, urorubin, etc.); urobilinogen, *hydroxybenzene derivatives* ("*alkaptonuria*"), *melanogen.* Urinary calculi and sediments—uroerythrin, urochrom hæmatoidin, indigo blue, bile pigments, hæmoglobin products. Vomit—blood, bile, food and drug pigments.

III. Chemical and Physical Qualities.

The animal pigments have been the subjects of many laborious researches, but, owing to the great difficulties they present to the investigator, our knowledge of the chemical characters of most of them is very slight and uncertain. The primary obstacle in the way of their proper chemical study is the strikingly minute amount in which they commonly occur, and, as nearly all of them have very great tinctorial power, their coloration effects, therefore, are usually out of all proportion to the actual quantity in which they are present in any medium. Further, isolation of the pigments by chemical means is apt to induce radical changes in them, for many are very unstable, and much confusion has resulted from failure to recognize this important fact. Nearly all of the animal coloring matters seem to have definite and characteristic effects on the spectrum, and may be differentiated, to a certain extent, by the number and position of their absorption bands. But even the extremely delicate indications of the spectroscope have undoubtedly led to error in some cases, since very wide spectroscopic differences may be brought about by very slight changes of molecular structure or physical condition, such as often result from ordinary chemical treatment. Consequently, there is good reason for believing that not a few of the coloring matters which have been dignified with special names are merely closely related artificial derivatives (oxides, reduction products, etc.) of several antecedent pigments or chromogens. It would carry us far beyond the scope of this particular article to present detailed reference to each of the pigments already mentioned. All of the most important are given due notice in more extended accounts of blood, urine, fæces, bile, etc., in these volumes, so that it will be sufficient here to describe, in conclusion, a few of the best known of those found in the lower animals.

Hæmocyanin (blue), chlorocruorin (green).—Each of these pigments is analogous to hæmoglobin in chemical structure and in function, the first replacing it in the hæmolymph of mollusks and related forms, the second in that of worms. Both, like hæmoglobin, unite loosely with oxygen; oxyhæmocyanin is blue, hæmocyanin itself is colorless. Hæmocyanin contains copper in place of iron and has no special influence on the spectrum. Chlorocruorin, on the other hand, yields hæmatin and shows characteristic absorption bands.

Turacin is a red, feather pigment. It possesses a spectrum which is almost identical with that of oxyhæmoglobin. It contains seven per cent. of copper, besides carbon, hydrogen, nitrogen, and oxygen. The quantity of turacin in the feathers of a single bird does not exceed two or three grains. It may be extracted from the feathers with 0.1 per cent. alkali and precipitated from its solution with dilute acid. It is insoluble in water, alcohol, and ether.

Carminic Acid (Carmin). — The female cochineal (Coccus cacti) contains from twenty-five to fifty per cent. of this coloring matter. The pigment is also found in the blossoms of certain plants. Its composition is shown by its formula: $C_{17}H_{18}O_{10}$. Some of its compounds produce effects on the spectrum analogous to those of oxyhæmoglobin. Carminic acid is a glucoside; when it is boiled with dilute acids, and thereby hydrated, it yields an optically inactive, non-fermentable sugar and also "carmin red" ($C_{11}H_{12}O_7$):

$$C_{17}H_{18}O_{10} + 2H_2O = C_{11}H_{12}O_7 + C_6H_{10}O_6.$$

Carminic acid may be extracted from the cochineal with warm water. The pigment is soluble in alcohol and dilute acids, and forms salts with alkalies and metallic compounds.

Punicin.—The colorless secretion of a glandular organ, situated at the lower part of the mantle, between the gill and the rectum of various species of Murex and Purpura, assumes, on exposure to light, a bluish-green color at first, then red, and lastly a purple-violet. This coloring matter, "Tyrian purple," is the "purple of the ancients" and for centuries was the dye of greatest beauty and value. Punicin is the name of the pigment; the chromogen has not been isolated. Punicin is insoluble in water, alcohol, and ether; soluble in boiling glacial acetic acid. It dissolves readily in boiling aniline, from which it separates, on cooling, in crystalline form.

Chlorophyll.—This important plant pigment is found in *Hydra viridis, Spongilla fluviatilus,* in the elytra of cantharides beetles, in the blood of many insects, in the so-called livers of many invertebrates, etc. It is insoluble in water, but dissolves in alcohol and ether, and consists of carbon, hydrogen, nitrogen, and oxygen, and possibly iron. Chlorophyll, treated with concentrated acid, yields phyllocyanin. The latter, on fusion with caustic soda, is transformed into phylloporphyrin ($C_{16}H_{18}N_2O$), a close relative of hæmatoporphyrin ($C_{16}H_{18}N_2O_3$), which may be produced from hæmoglobin, on treatment with acids, and is isomeric with bilirubin ($C_{16}H_{18}N_2O_3$.) Phylloporphyrin and hæmatoporphyrin are probably oxides of one and the same radicle. This kinship corresponds to analogous physiological relations of the pigments from which each can be derived.

Tetronerythrin (Crustaceorubin, Zoonerythrin).—The red pigment in the warty integument round the eyes, and also in the feathers, of various birds, and in the hypoderm and hæmolymph of many invertebrates, is one of the most widely distributed of all the pigments. It is soluble in ether, alcohol, and chloroform, and shows the absorption bands and gives the reactions of a typical lipochrom.

Lepidotic Acid.—The yellow pigment in the wings and excrements of butterflies (pieridinæ). It may be extracted with hot water or dilute alkalies, and is precipitated from such extracts on acidification. Its solutions show a greenish fluorescence and, on warming with dilute nitric acid, it yields uric acid. Warmed with dilute sulphuric acid a purple product, lepidoporphyrin, is obtained, which shows two characteristic absorption bands; this substance may also be derived directly from uric acid. The close relation of lepidotic acid to xanthin and uric acid is shown by the figures for their percentage composition:

	C.	H.	N.	O.
Xanthin (dioxypurin)	39.4	2.6	36.8	21.1
Lepidotic acid	38.1	3.5	37.1	21.3
Uric acid (trioxypurin)	35.7	2.4	33.3	28.6

William J. Gies.

COLTSFOOT. — *Tussilago. Farfara.* The plant *Tussilago Farfara* L. (fam. *Compositæ*). This is a perennial herb with a branched and creeping root stock which sends up in the early spring numerous simple scaly flower stems, and later in the season large, angular, heart-shaped leaves. It is common in rich, moist places in Europe and Asia, and occasional in the United States.

The rhizome, leaves, and flower heads have been separately employed. The leaves, which have been most used, contain gum, tannin, and a bitter glucoside, besides a slight amount of an unknown odorous principle. The drug possesses no very active properties. It has been used chiefly as an expectorant and mild tonic. Its use is now mostly confined to patent medicine and domestic practice.

Coltsfoot is the only species of its genus, but the next genus, *Petasites*, resembles it very closely, and has several species which have enjoyed about the same reputation as coltsfoot.

This name is also applied, in some sections of the United States, to *Snakeroot*, Canada, which see.

Henry H. Rusby.

COLTSTAIL. See *Erigeron.*

COLUMBIA SPRINGS.—Columbia County, New York.

Post-Office.—Hudson. Hotel.

Access.—Viâ New York Central and Hudson River Railroad, or by steamer on the Hudson River to Hudson, 115 miles north of New York and 27 miles south of Albany; thence 4 miles northeast by carriage to springs.

This is a very pleasant, quiet resort, where salubrious air and charming rural scenery may be enjoyed. The springs are four in number. An analysis by Professor Atwood shows the following contents:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	21.79
Sodium hyposulphite	8.15
Calcium sulphate	64.94
Sodium phosphate	2.14
Sodium chloride	84.72
Potassium chloride	1.19
Magnesium chloride	31.43
Iron sesquichloride	3.42
Loss	.82
Total	218.60

Sulphureted hydrogen gas, 4.49 cubic inches.

This analysis shows a very valuable saline-sulphur water, with a considerable proportion of iron. A new examination is desirable, as we are informed that this analysis was made many years ago.

James K. Crook.

COLUMBO.—CALUMBA. "The root of *Jateorhiza palmata* (Lam.) Miers (fam. *Menispermaceæ*)" (U. S. P.)

The columbo plant is a large, perennial climber, often ascending to the tops of the loftiest trees, with a rounded, thick, yellow rhizome, from which numerous fleshy roots are given off. These roots are fusiform, resembling long dahlia or sweet-potato roots, attached to the also tuberous root stock. They are dug up, sliced transversely, and dried in the shade.

Columbo is a native of Mozambique, Zanzibar, and the adjacent lands of tropical Africa, and is said to be cultivated.

The dried sliced root has a very characteristic appearance. It is in circular discs from 1 to 5 or 6 cm. in diameter ($\frac{1}{2}$ to 2 in.), and from one-fifth to one-half inch in thickness; the edge (surface of the root) is brown and rough; the flat surface (sections of the root) lemon-yellow, and depressed in the middle from collapse of the soft, thin-walled cells of the pith in drying. A dark circle marks the cambium, and one or two indistinct circles of woody bundles can be seen within it. The tissue is chiefly parenchyma, loaded with starch.

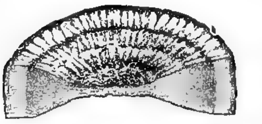
FIG. 1473.—Section of Calumba, About Natural Size. (Baillon.)

Columbo contains several bitter principles. One of them, *berberine,* is found in several other plants (see *Barberry*). *Columbin* is a colorless crystalline substance of excessively bitter taste and neutral reaction. *Columbic acid* is a yellow amorphous powder, also bitter. The medicine owes its value to all these constituents. Besides these, it contains starch and mucilaginous substances.

None of the active principles of columbo are in any degree poisonous. They unite in making it a simple bitter tonic.

The dose of the powdered root is from 0.5 to 1 gm. (gr. viij. ad xvi.), but it is seldom employed so. A fluid extract and a ten-per-cent. tincture are official.

W. P. Bolles.

COLUMNÆ ADIPOSÆ. See *Skin.*

COMANJILLA.—Guanajuato, Mexico. There are about eighteen of these springs. On account of their heat they are called "Calderas." The waters have a temperature of 96° C., and are therefore considered the hottest springs in the world. Amongst other substances they contain carbonate of lime and sulphate and oxide of alumina.

They are very useful in rheumatism, syphilis, and diseases of the skin.

N. J. Ponce de Léon.

COMEDO.—(Synonyms: Blackheads, acne punctata; Ger., *Mittesser*; Fr., *Verres bleues.*)

DEFINITION.—A comedo has most usually been defined as a collection of sebaceous matter in the excretory duct of a sebaceous gland. More correctly, the blackhead is a parakeratosis of the epidermic lining of the duct and encloses between its concentric layers and in its central portion a variable amount of sebaceous matter.

SYMPTOMATOLOGY.—Comedones or blackheads are represented by slightly prominent and elevated, but in some instances depressed and discolored, points occupying and corresponding to the external follicular orifices of the sebaceous glands. They occur especially on the face, forehead, and cheeks, but also on the temples, around and in the ears, on the neck, the back, and the chest. They have also been seen frequently on the penis, scrotum, mons veneris, and on other parts of the body supplied with fat glands. Comedones may occur singly and may be distributed in a discrete manner, or they may be closely aggregated and packed together. In some cases only a few may be present, while in others they may be so numerous that the skin has a discolored, dirty and rough appearance. In their color and in their size great variations may be seen. In color, they may be light yellow, or brown, bluish, and even black, while in size they may occur as minute dark points—on the chin producing a dusky appearance; or, as on the nose, cheeks, or back, the individual lesion may be as large as a pinhead or even larger.

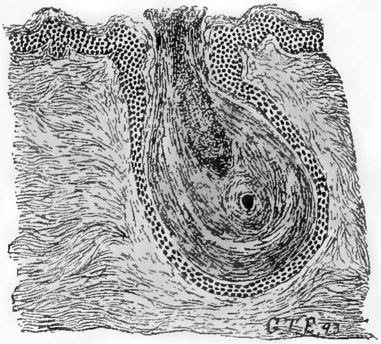
FIG. 1474.—Section of a Comedo from the Back. (Original.)

Usually single, it is not unusual to meet with a double comedo, that is, one which, while consisting of one body, yet occupies two or more ducts of separate glands. When this is the case, the dark points are grouped together, separated by narrow bridges of normal skin. Pressure does not cause extrusion of one blackhead, but of all at the same time. Another type of comedo, which has been described, is constituted of "grouped comedones" (Crocker). They occur occasionally on the trunk, but particularly on the cheeks, forming symmetrical groups of densely crowded black points. They show no tendency to inflammatory reaction and suppuration. On the temples, on the lobes of the ears, and on the chest, small, papular, whitish elevations are often seen, which on pressure yield a soft, white, filiform body resembling vermicelli sticks. They are usually classed with comedones, but are in reality small retention cysts, the sebaceous matter being accumulated in the gland body and not implicating the duct in any way. (They should not be confounded with milia, however, as the contents of these latter cannot be squeezed out.)

When pressure is applied to a comedo, a somewhat dense, resistant, more or less globular or ovoid body emerges from the follicular canal. Its outer end is yellow to black, its body is yellowish, while the lower end is soft and white, consisting of sebaceous matter from the gland body itself. The life history of a comedo is of variable duration. It may be removed by washing or rubbing, or it may persist unchanged for a long time. Inflammation of the cutaneous tissues surrounding it may and most frequently does occur, and results in the formation of a pustular lesion—an acne pustule.

Etiology.—Puberty is accused of being the most frequent and constant cause of the comedo formation. It certainly occurs most usually at or about that age, but it is also not uncommon in younger children and even in infants. That the comedo may also develop much later and in adult life is a matter of too frequent observation to constitute a rarity. The active hair growth which takes place at puberty has been regarded as an important etiological factor, as well as a want of tonicity of the walls of the follicular canal; but in all probability the physiological rather than the anatomical conditions in the evolution of the sebaceous glands at the age of development should be considered. At any rate, it can be said that coincident with the origin of the blackheads, there are also found one or more of those defects of nutrition, or those systemic disturbances so usually present at the time of puberty, such as anæmia, constipation, gastric and intestinal disturbances, errors of diet, etc. The comedo formation has also been ascribed to uncleanliness, but, except under exceptional circumstances, this condition can scarcely act as a factor. Comedones are not uncommonly, however, of artificial origin. That is to say, the external appearances characteristic of a comedo may be due to some foreign substances blocking up the orifice of a sebaceous gland. Among such, tar may be mentioned especially, and similar conditions may be seen in workers in brass and iron factories and workshops, or in firemen, oilers, or stokers. In other words, any substance blocking up the orifice of a sebaceous gland may simulate a comedo.

Pathology and Morbid Anatomy.—A comedo has usually been considered as an accumulation of sebum in the duct of a sebaceous gland. The causes of the accumulation have been ascribed to a loss in tonicity and contractility of the walls of the ducts, and the improper fatty degeneration of the glandular cells has also been brought into the question. More lately (Unna), the development of the comedo has been attributed to a parakeratosis of the external stratum corneum and that portion of it lining the duct of the gland. The cause of this hyperplasia of the horny layer is claimed by Unna to be a minute bacillus, but corroboration of his claim is still wanting. Kaposi, in view of Biesiadecki's investigations, had also long before claimed that the corneous and outer layer of a comedo was due to a hyperplasia of the epidermic lining of the duct, but he had considered the irritation from the impinging of lanugo hairs on the walls as the cause of the thickening. At any rate, a comedo cannot be regarded as simply a sebum plug, since histologically it will be found to be made up for the most part of concentric layers of horny epidermis surrounding a central cone of sebum, lanugo hairs, and epidermic scales. At times the acarus or demodex folliculorum may be present, but it is not of any particular consequence in human beings.

The color of the outer end of a comedo is generally ascribed to dust, particles of dirt, etc. Unna has claimed that it was due to ultramarine normally present in the secretions and to a darkening of the horny plug consequent upon exposure to the air. Owing to the inconsequence of the subject, definite or corroborative investigations have not been made.

The double comedo does not differ in origin from the ordinary or single lesion. The fact, however, that it communicates with a single cavity has been shown to be due to pressure atrophy. Two contiguous sebaceous glands, becoming each plugged up with a comedo, does not cause cessation of glandular secretion. The resulting accumulation leads to mutual distention, pressure, absorption of intervening tissue, and ultimately to formation of a single cavity.

The pathological importance of a comedo resides in its intimate relationship to acne. It very usually constitutes the point of origin of a perifolliculitis and a folliculitis, or, in other words, of an acne pustule.

Diagnosis.—There should be no difficulty in recognizing comedones. Their localization, their situation in the follicular orifices, their color, and the fact that they so commonly are a focus for perifollicular inflammation and suppuration should readily obligate their recognition.

Prognosis.—The outlook in the case of comedones is always favorable, except that their presence usually leads to the development of an acne. The process is one amenable to treatment, though complete cessation in their development is difficult of attainment. In some individuals, the period during which they appear is of short duration, in others the predisposition may exist during life.

Treatment.—Particular importance in all cases of comedones should be given to the systemic health. Investigation should be made for any and all etiological factors which may be in existence, and these, whatever they may be, should be removed. Anæmia, gastric or intestinal or other derangements, should be corrected, and the same attention to the general and functional health should be given as would be done in a full-fledged case of acne. The diet should be regulated. Sweets, candies, oatmeal, cheese, nuts, rich entrées, etc., should be expressly forbidden, and the regimen be made a plain but nutritious one. Moderate outdoor exercise and attention to general hygiene is called for, as well as all other matters which may conduce to improvement of the patient's bodily conditions. The *local treatment* is also of great importance. The comedones may be removed mechanically by means of a comedo extractor, such as are found at any instrument maker's. This, however, should be done by the physician and not entrusted to the patient, and should be followed by the application of that one or other local application ordered in the case. Scraping the surface with a sharp curette has also been recommended; but it does not remove more than the outer portion of the comedo, which then quickly reforms. The operation is likewise painful and disfiguring, and in the writer's experience demands a very submissive patient. Face massage is a means of removal advocated by advertising so-called complexion specialists. The comedones are removed, but the ultimate results are usually disastrous. The same statements may be made in regard to face steaming, as the process is not disposed of simply by removing the comedo. It is the patient and his skin who require such care and such appropriate treatment as will prevent the re-formation of the comedo after its removal that is necessary. In view of what has just been stated, it may be understood that all purely local remedies are therefore only such as are aids to the general systemic treatment. An efficacious and simple remedy, which softens and removes the blackhead, is an ointment: ℞ Sod. borat., ʒ ij.; Ungt. aq. rosæ, ℥ i. M. Sig.: Apply freely, and after a half to one hour wash off with soap and *cold* water. Then apply one or the other of these lotions: ℞ Zinci sulphat., Kali sulphuret, Sulph. lact., āā gr. xv.; Aq. rosæ, ℥ i. M. and S.; or ℞ $HgCl_2$, gr. ij.; Acid. acetic. dil., ʒ vi.; Aq. rosæ, Spts. vini, āā ℥ ss. M. and S.; or a saturated solution of salicylic acid in alcohol may be used. The latter causes a free exfoliation of the horny epidermis, and the comedones are frequently removed entirely by its means. Among ointments, there may also be mentioned the Ungt. hydrarg. ammoniat., 5 to 10 per cent.; Ungt. resorcin., 3 to 10 per cent.; Ungt. sulphur., 5 to 10 per cent.; etc. Soap and cold-water washings twice a day are of great value. The kind of soap is not of importance, so long as it is a neutral one and does not contain an excess of lye. However, soaps with sand or with marble dust have been recommended, as well as the tincture of green soap, and also a host of medicated soaps with which the market is to-day inundated; but when it is borne in mind that the cause of the comedo formation is the important factor requiring treatment, it can be judged that all of these are only subsidiary and not agents of any special value.

George T. Elliot.

COMFREY.—Symphytum. The root of *Symphytum officinale* L. (fam. *Boraginaceæ*). This is a coarse, rough, perennial herb of Europe, sparingly naturalized in the United States. For medicinal use the root is gathered in autumn, split longitudinally, and rapidly dried. It is then furrowed and wrinkled, with a black surface and bluish-gray section. It occurs mostly in pieces from one to four inches in length and of the thickness of a lead-pencil or less. Its texture is hard and horny; fracture, cellular; taste, mucilaginous, slightly bitter, and astringent.

Comfrey has been long in use, first as a vulnerary, and afterward as a demulcent and "pectoral"; its constituents are similar to most others of its class: *mucilage, sugar, asparagin, tannic* and *gallic acids*, and *starch*. Dose—a decoction may be taken *ad libitum*.

The *leaves* have a similar composition and use.

Henry H. Rusby.

COMMONWEALTH MINERAL SPRINGS.—Middlesex County, Massachusetts.

Post-Office.—Waltham.

This spring is located in the extreme northern part of the town of Waltham. It yields ten gallons of water per minute, having a temperature of 48° F. the year round. An analysis by Prof. S. Dana Hayes, the State assayer, in 1879, resulted as follows:

One United States Gallon Contains:

Solids.	Grains.
Sodium bicarbonate	0.50
Magnesium bicarbonate	.18
Lime bicarbonate	.45
Potassium sulphate	.61
Sodium chloride	.34
Silicic acid (in solution)	.37
Iron and alumina	Merest traces.
Total	2.45

The water is naturally charged with oxygen, nitrogen, and carbonic-acid gases. It is clear and sparkling and quite free from any appreciable organic matter. The water is bottled and sold extensively in Massachusetts. It is also used in making a number of pleasant beverages. The water is said to have a satisfactory influence in some of the functional disturbances of the liver, kidneys, stomach, and blood.

James K. Crook.

COMPOSITÆ.—(*The Daisy Family.*) Taken in its broad sense, as generally regarded, this is our largest family of plants, comprising more than eight hundred genera and more than ten thousand species, though some authorities reduce the number by separating, as distinct families, a number of our sub-orders. There is scarcely any flora of the earth where these plants are not found, or even where they are not abundant. Their economic importance is great, as ornamental plants and to some extent as foods. Among the latter are the artichokes, salsify, burdock, several plants of the thistle group, lettuce, and chicory. Starch is largely wanting in the family, its place being filled by the closely related *inulin*, and this is the important nutrient constituent. Medicinally, the family represents three classes of agents, dependent upon distinct classes of constituents. We have first, stomachics and tonics, dependent upon volatile oils and bitter substances. In some cases, as in the iron weeds (*Vernonia*), the bitter element is almost alone; in others, like Erigeron, the volatile oil is nearly devoid of bitter association. In some cases, moderate quantities of tannin are also present. Occasionally, these substances are anthelmintic, as in santonica, or insecticidal, as in the insect flowers.

The second class of remedies depend upon resins or powerful volatile oils for their counter-irritant properties. Internally they are powerfully irritant, to the extent of being poisonous, like arnica, pyrethrum, or tansy.

Thirdly we have a few milky juiced plants of the suborder *Cichoriaceæ*, with laxative and alterative properties, like dandelion and chicory, or even narcotic like lactucarium. A few, like absinthium, possess peculiar properties, due to special constituents. An enumeration of all the drugs of this family in domestic and aboriginal use would carry us far into the hundreds, yet the total medicinal importance of the family cannot be regarded as other than minor.

Henry H. Rusby.

CONCA.—Queretaro, Mexico. These waters, besides being employed in rheumatism and leprosy, are supposed to be of benefit in menstrual derangements.

N. J. Ponce de Léon.

CONCRETIONS AND CALCULI.—Concretions and calculi are terms applied in medicine to aggregations of solid, more or less hard substances, which form in the body tissues or fluids and act as foreign bodies. The substances composing the aggregations are usually such as are formed in the tissues and fluids normally or pathologically, and may be either organic or inorganic substances, or a mixture of both; occasionally, however, foreign matter finds its way into some part of the body and acts as a nucleus for a calculus. Crystalline, granular, or amorphous masses may be deposited in a tissue and thus cause it to assume a hardened state; or the latter condition may result from the absorption of fluid. The terms petrifaction and calcification are applied to such hardenings so long as the tissue in which the change occurs bears its normal relation to the surrounding parts; but when this relationship ceases and the hardened area acts as a foreign body, then it is proper to employ the terms concretion or calculus, whether the mass is embedded in the tissues or lies free in some cavity.

Chemically, the change most frequently results from a deposit of calcium carbonate or phosphate with perhaps in addition a small amount of magnesium salts. The process is apt to accompany or follow degeneration or death of tissue; in fact, it seems as though tissue undergoing necrobiosis has a special attraction for calcium salts. Connective tissue undergoing hyaline degeneration with accompanying calcification is often encountered in the walls of the blood-vessels, in the endocardium, in the thyroid, and in the thickened pleura, and may be found in other portions of the body. Calcification of tuberculous areas, uterine fibroids, and ovarian and other cysts is also frequent. Under exceptional conditions, and more particularly in advanced age, the process occurs in tissue in which degenerative changes are not recognizable. In rare instances calcareous infiltration is believed to be due to an absolute increase of calcium salts in the blood, such as perhaps occurs in extensive caries and in osteomalacia. This is certainly unusual, but some observations seem to support the view.

Amyloid concretions, or corpora amylacea, are small, oval, homogeneous or laminated bodies that frequently occur in the tissues of the nervous system and in the prostate. In the nervous system they are especially apt to occur in conditions of atrophy or softening. The ependyma of the ventricles, the white substance of the brain, the choroid plexus, the optic nerve, and the spinal cord are their favorite seats. They are occasionally met with in the lungs, in mucous and serous membranes, and in extravasations of blood. Amyloid bodies were formerly believed to consist of amyloid substance. While it is true that they may assume a bluish color on treatment with solution of iodine or iodine and sulphuric acid, and resemble somewhat in structure the product of progressive amyloid change, it is now recognized that their formation is dependent on local changes, and it is not believed that they are similar to the product of amyloid degeneration. Redlich considers the corpora amylacea of the nervous system, which stain similarly to nuclei with hæmatoxylin, to be made up of the nuclei of neuroglia cells and to be a senile retrograde development of the tissue. Stroebe believes them to be composed of fragments of swollen axis cylinders, while Siegert believes them to have originated from cells. In the choroid plexus and lateral ventricles they frequently become calcified and then constitute one form of "*brain sand.*"

Biliary concretions are both frequent and of clinical importance. Europeans have found gall stones in from five to ten per cent. of all autopsies; in the East, on the contrary, they are extremely rare, only one or two cases being recorded.

The stones are usually found within the gall bladder, less frequently in the cystic or common duct and in the alimentary tract, having passed down from the gall bladder, and in rare instances they occur in the intrahepatic ducts. Biliary fistulæ are not uncommon, and through these abnormal communications gall stones have been known to pass to the outside of the body, into the abdominal cavity, into the stomach or intestines, into a liver abscess, into the portal vein, or into the urinary passages, and records are not rare in which they have entered the lungs. A single calculus may be present in the gall bladder, in which case it is usually ovoid and may be quite large; or the number may be very great, 7,802 having been reported in one case. The usual number is between four and fifty, and the average size is apt to vary inversely with the number, from that of a pinhead to a cherry. When numerous they may be the size of small grains, while, on the other hand, Meckel has described a single biliary calculus 15 cm. long and 6 broad. When more than a few are present they commonly lose their ovoid shape and show signs of mutual pressure, having a polygonal form with smooth facets. All those present in the same individual commonly have the same chemical composition and present the same physical characters, but may vary considerably in size.

Chemical analysis has shown that the vast majority of biliary calculi are composed chiefly of either or both of two substances, viz., cholesterin and the calcium salt of bile pigment, known as bilirubin-calcium. Either of the two substances may be the sole constituent or they may together form the mixed varieties, with the two substances in almost any proportion. Certain materials only occasionally enter into the composition of gall stones or do so commonly only in very small amount: such are inorganic calcium salts, notably the carbonate, sulphate, and phosphate, small quantities of copper, traces of iron, zinc and manganese, globules of mercury, fats, silica, uric acid, and foreign bodies. Of these latter the round worm, a portion of distoma hepaticum, a needle and a plum stone have each been recorded as being the nucleus of a calculus. The presence of calcium salts in mixed calculi, particularly the carbonate, contributes hardness; in rare instances the concretion may be chiefly or entirely calcareous. The bile acids and other constituents of bile are found in calculi only in such traces as are explained by the absorption of this fluid in the interstices. Again, the bile pigment in combination with calcium is not always bilirubin, but frequently in part biliverdin or bilifuscin.

It may be said that in general cholesterin predominates in the larger stones, while the smaller are more apt to contain considerable bilirubin-calcium. Naunyn, in his admirable treatise on cholelithiasis, recognizes six classes of gall stones:

1. *Pure Cholesterin.*—Usually pure white or yellowish, translucent: in rare instances dark colored. Ordinarily oval or roughly spherical in form, hard, seldom exhibit facets, not stratified or only feebly so and vary in size from a cherry to a pigeon egg.

2. *Laminated Cholesterin.*—Contain ninety per cent. or more of cholesterin, the other constituents being calcium compounds of the bile colors and calcium carbonate. Are usually hard, but occasionally when dry, brittle, and friable, more frequently facetted than the first variety, more or less distinctly laminated, with the layers perhaps differing in color, often with those nearer the centre more crystalline in structure and those nearer the surface hardened by the presence of calcium carbonate. They resemble pure cholesterin stones in form and size, but are apt to be somewhat darker in color.

3. *Common Gall Stones.*—These comprise the great bulk of gall stones, varying in size (pinhead to cherry), in composition, and in form and tint. Usually facetted and laminated. The soft nucleus may consist of bilirubin-calcium, or the centre may consist of a cavity holding a yellowish alkaline liquid. If soft when removed they harden and shrink on drying, without developing fissures.

4. *Mixed Bilirubin-calcium.*—Usually the size of a cherry, occur in groups of three or four, and are facetted. They are twenty-five per cent. or less cholesterin, the remainder being chiefly bilirubin-calcium. They have a brown color, are seldom hard, and develop fissures when they dry.

5. *Pure Bilirubin-calcium.*—Common in cattle, rare in man. Vary in size from a grain of sand to a pea, being the stones that are sometimes observed in the intrahepatic bile ducts. The smaller ones may have a wax-like consistence, with brownish-black, rough, irregular surface, while the larger ones usually are brittle, have a smooth surface, and a gray to black color with a metallic lustre. In calculi of this class bilifuscin is practically always present.

6. *Rarer Forms.*—(*a*) Amorphous and incompletely crystalline cholesterin gravel: small, often resembling pearls, and always with a nucleus of different structure. (*b*) Calcareous, consisting almost entirely of calcium carbonate. (*c*) Concretions which include foreign bodies and conglomerate stones. (*d*) Casts of bile ducts.

As to the source of cholesterin in bile, Austin Flint more than a third of a century ago presented the view that the separation of this constituent from the blood by the liver is a regular and important function of this organ. Since, however, it is not increased in bile by the character of the diet or the administration or subcutaneous injection of cholesterin, recent observers have come to believe that it is independent of the amount in the blood. It may be that small amounts are regularly separated, as Flint held, by this organ, but the observations of Naunyn, confirmed by Hunter, present considerable evidence that at least most of the cholesterin of calculi is formed *in situ*, being a product of the diseased mucous membrane of the biliary passages. This conclusion accords with its frequent formation as a product of degenerative conditions in other locations, *e.g.*, in cysts and in the secretions of other diseased mucous membranes, as, for example, its occurrence in the sputum of bronchitis. Naunyn observed myelin globules within the degenerating epithelial cells of the biliary passages, and especially of the gall bladder, which escape in a viscous condition and are to be seen floating about in the bile. On the addition of acetic acid these masses solidify into a mass of cholesterin crystals. According to this view, then, the cholesterin of concretions has never been in solution in bile at all. In further support of the local origin is the fact that although the small amount normally present in bile is held in solution by the bile salts, soaps and fats, the formation of cholesterin-containing calculi does not appear to be associated with their diminution.

Bilirubin-calcium is not a normal biliary constituent, and its occurrence in concretions, therefore, demands a further explanation than the mere presence of bile color. The exact origin has not yet been conclusively demonstrated. If lime be added to bile the formation of this compound, being hindered by the presence of bile salts, is not accomplished until large quantities have been added; the mere secretion of calcium in excess does not therefore adequately explain the formation. Moreover, calcium is not secreted in excess when it is present in increased amount in the food and drinking water, as has been held. What has been observed is that the presence of albumin overcomes the retarding influence of bile salts on bilirubin-calcium-formation; and it seems in all probability that this condition, viz., the presence of albumin in bile, is the deciding factor. Whether its presence is dependent on the disintegration of epithelium resulting from catarrh of the mucous surfaces, as was suggested by Naunyn, is not known, but it is not unreasonable to believe that at times albumin may pass from the blood through the hepatic cells into the bile in much the same way as in nephritis it passes into the urine in the kidney. If the explanations advanced are correct, it will be seen that the conditions leading to the separation of the two chief constituents of gall stones are essentially local, namely, epithelial degeneration and the catarrhal and inflammatory conditions of the bile ducts and passages that lead to the presence of albuminous substances.

Naunyn's views find support in clinical experience and are interesting, though not universally accepted. Thudichum holds that gall stones contain ingredients found in bile only after its decomposition and that the mucous glands of the gall-bladder do not participate in their production (Fig. 1475).

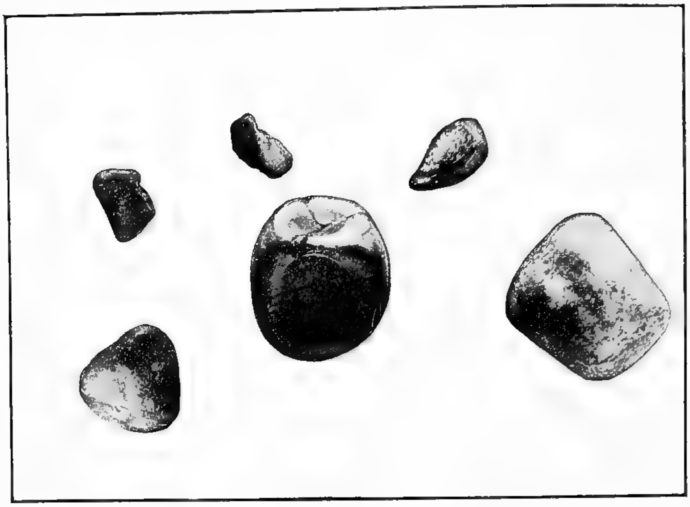

FIG. 1475.—Biliary Calculi, Facetted, of Impure Cholesterin, Removed from a Gall Bladder. (Natural size.)

According to the older view of Frerichs and others the etiological factors in cholelithiasis are advanced age, female sex, pregnancy, tight lacing, and sedentary habits,—conditions favoring retention of bile. From what has been said, it follows that this is so only to the extent that stagnation is a factor in the production and continuance of infection of the biliary passages, which in late years has been recognized as the immediate cause of stone formation, certainly in the great majority of instances. The infecting agents that have chiefly attracted attention are the colon bacillus and the typhoid bacillus, but it is known that in individual cases the pyogenic organisms as well are intruders.

Particular interest is attached to the occurrence of gall stones following typhoid fever: it is probable that in some cases the infection of the bile with the typhoid bacillus persists for months and even years, and that in many instances it determines inflammatory conditions of the biliary passages that directly lead to the formation of biliary calculi. It has been suggested that groups of typhoid bacilli become the nuclei of concretions, and observations seem to support this view. If so, it is not improbable that in some instances the bile, which is known to acquire the property of causing the bacilli to clump, actually leads to the formation of nuclei by agglutinating the typhoid bacilli contained in it.

The invasion of the various organs by the colon bacillus is now too well recognized to require argument of the possibility of such an occurrence in the case of the bile passages. Instances are not uncommon in which for some reason the bacillus is particularly virulent and the tissues less resistant than normal, and in which, consequently, the bacteria invade the liver and bile passages. Under these circumstances, especially if associated with stagnation of bile, the conditions are ripe that favor the formation of biliary calculi.

Calculus formation commonly originates from (1) epithelium in bile, (2) sedimentary masses, or (3) agglutinated bacilli; less commonly from the adhering together of small nodular masses of pure bilirubin-calcium or cholesterin. The growth is both by the addition of fresh layers and transformation within the calculus; this is rendered possible by the existence of minute infiltration channels through which there is continuous progressive infiltration with cholesterin and its deposit in crystalline form. Even pure cholesterin calculi do not crystallize directly from solution, but are secondary formations. The layers deposited on the surface of calculi are as a rule, hardly more than 1 mm. thick, but if rich in bilirubin-calcium they may be 5 mm. thick or more. Early in the formation of some calculi, even while they are acquiring a firm crust, changes may occur in the soft interior: either the contents may deposit on the firm crust, leaving a hollow interior, or such a deposit may leave the contents fluid. The growth of the concretion by deposit of bilirubin-calcium ceases when bile ceases to enter the bladder, but the acquisition of cholesterin from the mucous membrane may continue.

Cardiac calculi, so called, are found in rare instances, at the necropsy, lying free in the pericardial sac. Some are soft and smooth, varying in size from a pea to a bean; others firm, fibrous, occasionally stratified or calcified, either in a central nucleus or throughout. They are regarded either as polypi detached from the inner surface of the pericardium, or as results of fibrinous or calcareous deposits about some foreign substance.

Cutaneous concretions are nodular calcareous deposits in the cutis or still oftener in the hypoderm. They are usually surrounded by capsules of firm connective tissue from which septa extend into the contents of the tumor, dividing it into segments which are made up of calcified cells. True ossification of these septa has been observed, though this is exceptional, they being usually fibrinous or calcareous.

Views regarding the nature of the cellular masses differ according to the explanation of the development of the tumor which the observer accepts. Malherbe believes that the majority of cutaneous stones develop from proliferated and cystic sebaceous glands. Von Noorden reports a stony, hard, pear-shaped tumor, which hung behind the ear by a peduncle and in which the epithelial collections looked like concentric, horny pearls and which in spite of its benignancy he classed with carcinoma. Four small tumors of the skin of the scrotum, in a boy of twelve, were regarded by Lewinski to be calcified lymph thrombi. While all sorts of degenerated tissue and inspissated secretion may take up calcium salts and lead to the formation of stone, Unna believes that fat and fat products have a special tendency to this, owing to the formation of insoluble calcium soaps by the reaction with calcium bicarbonate of the lymph. He differs from Malherbe in believing that calcification involves glands only in so far as they are enclosed in fat lobules.

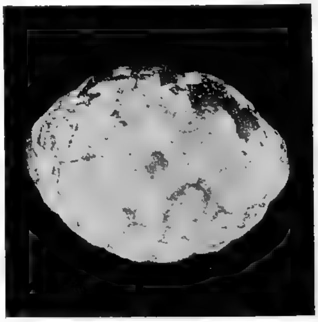

FIG. 1476.—Biliary Calculus from Cystic Duct: case of empyema of gall bladder. (Slightly enlarged. The actual specimen measured one inch and one-quarter in its long diameter.)

Skin concretions are of rare occurrence. They have been more frequently found in the aged.

In the course of *gout* a deposit of tophi composed of biurates is common, most often in the kidneys, skin, and subcutaneous tissue, but also frequently in the tendon sheaths, the tendons, ligaments, synovial membranes and articular cartilages, and ultimately perhaps in nearly every tissue and organ in the body, excepting tissues of the nervous system. The composition is indicated in the following analysis of such a concretion by Ebstein and Sprague.

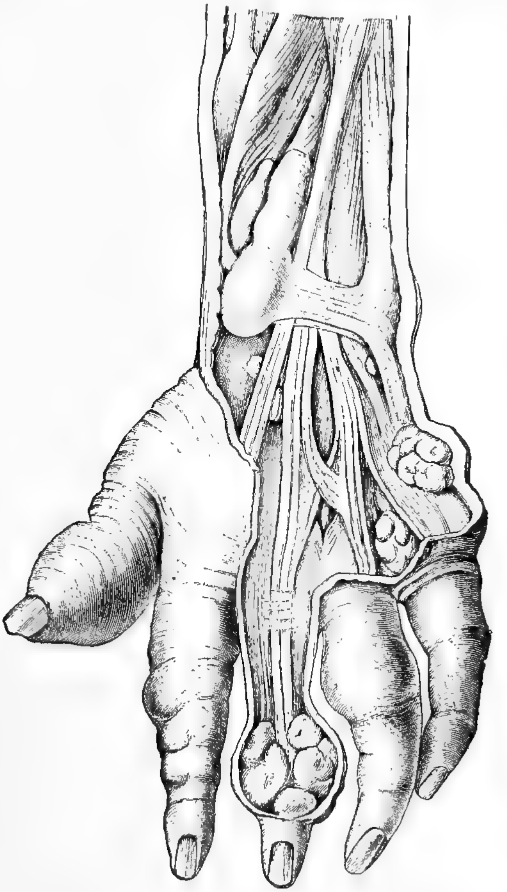

FIG. 1477.—Gouty Nodes of the Hand. (After Lancereaux.)

ONE HUNDRED PARTS OF SOLIDS CONTAINED:

Uric acid	59.70
Tissue organic matter	27.88
Na_2O	9.30
K_2O	2.95
CaO	.17
MgO, Fe, P_2O_5, S	Traces.

The views of various observers differ as to the cause of the formation of gouty concretions. The earlier view of Garrod and others was to the effect that uric acid is present in undue amount in the blood and separates as tophi owing to the sluggish circulation in the various locations. Ebstein advanced the opinion that the deposit is determined by tissue necrosis preceding the formation of concretions. Others (Bouchard, E. Pfeiffer) held that diminished alkalinity of the blood is the prevailing etiological factor. Von Noorden believes that tissue necrosis in gouty conditions is of such a kind as to lead to urate formation from cell products at the site of the concretion and that the material of tophi is not directly brought to the area by the blood. It is at least certain that although in leukæmia and some other conditions uric acid is formed in the body in large excess, it does not lead to the deposit of the tophi so characteristic of gout (Fig. 1477).

Intestinal calculi, or *enteroliths*, occur more frequently in herbivorous animals than in man. In certain animals, which have the habit of licking their own coats or those of their associates, the formation in the stomach and intestines of balls of felted hair is not infrequent; these hair balls perhaps attaining considerable size. Commonly, intestinal concretions are found in the colon and are very small, rarely as large as a hazelnut, so that it is very infrequent for them to cause obstruction. We have already mentioned that gall stones may enter the alimentary tract. Various foreign substances are introduced through the mouth and œsophagus, a very small percentage of which become nuclei of concretions. In most instances the central mass consists of undigested food residue or inspissated mucus, while the material composing the bulk of the calculus is commonly ammonium magnesium phosphate, perhaps with magnesium phosphate, but may include calcium phosphate and carbonate and occasionally calcium and magnesium soaps and albuminous matter. I have seen one small concretion, which the patient said passed per rectum, which appeared to be identical with urostealith, presenting the characteristic appearance and giving the chemical reactions of this substance. In countries where oatmeal is largely eaten, often as a substitute for bread, intestinal concretions resembling hair balls are not infrequent; they contain calcium and magnesium phosphate, about 70 per cent.; oatmeal bran, 15–18 per cent.; soaps and fats, about 10 per cent.

Oriental "bezoars" are intestinal concretions which probably were formed in *Capra ægarus* and *Antelope dorias*. They are usually spherical or oval and have a dark olive-green color due to biliverdin, with a smooth, shining exterior, and are composed almost entirely of lithofellic acid, $C_{22}H_{36}O_4$, soluble in boiling alcohol from which the acid separates on evaporation as small pointed rhombohedra or three-sided prisms. This acid is insoluble in water and ether, but dissolves in glacial acetic acid. It is closely related to cholalic acid. When heated, true bezoars evolve aromatic fumes.

False bezoars, which come from Eastern countries, have a brownish-black color, do not melt or evolve aromatic fumes when heated, and are composed chiefly of ellagic acid, $C_{14}H_{16}O_8 + 2H_2O$, probably derived from the tannins contained in the food consumed by the animals which yield them.

Pancreatic calculi are usually small, varying in size from a grain of sand to a walnut; multiple, numbering from one to more than a hundred, and of light gray or white color. They are usually round or oblong, sometimes elongated and branched. The surface may be smooth, rough, or spinous. They are composed chiefly of calcium carbonate, but contain some calcium phosphate and occasionally cholesterin. They may be the cause of pancreatic cysts and chronic pancreatitis.

Preputial concretions sometimes form in those cases in which the prepuce cannot be drawn over the glans, and they usually have for their nucleus dried smegma, around which may be deposited the ordinary constituents of urinary calculi, especially the phosphates. Some of these concretions have been found to consist of dried smegma and epithelial scales: one, analyzed by Zahn, was made up of epithelium, calcium salts, and cholesterin, and another examined by E. Salkowski gave fat, free fatty acids, and calcium salts.

Prostatic concretions, which are of frequent occurrence, may originate in the substance of the gland, may come from the bladder or the urethra, or may be deposited from the urine in suppurating prostatic pouches. Those that are present in the substance of the gland usually originate as the amyloid bodies already described, which indeed are so constantly present in this organ that they can hardly be considered abnormal. As they increase in size, in most instances in later adult life, they excite inflammation and become hardened by the deposition of calcium salts, particularly the phosphate and carbonate. These calculi may lie separately in pouches or several may be together in a common pouch, in which instance they are often adherent or exhibit facets. Their color is brown or black, and the surface smooth and polished.

Those coming from the bladder and those forming from urine present the characters of vesical calculi formed under similar conditions; they consist most frequently of a mixture of calcium and ammonio-magnesium phosphates. Dr. Herbert Barker has described a large prostatic calculus which was pear-shaped, measured four and seven-eighths inches in length and four and five-eighths inches in circumference, and weighed 1,681 grains.

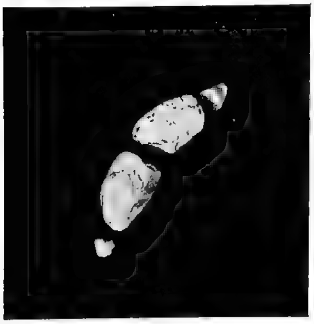

FIG. 1478.—Salivary Concretion from Wharton's Duct. (Natural size.)

Pulmonary calculi are most frequently found in the lumen of bronchi, but may occur in air vesicles and even on the walls of pulmonary cavities. Those formed in the bronchi are composed of inspissated and calcified mucus or blood, calcified broken-down bronchial glands, or incrustated foreign bodies. In pulmonary cavities or air vesicles a portion of the wall becomes incrusted or impregnated with dust of various kinds and is subsequently thrown off by necrosis. A case of lenticular necrosis in a stonecutter's lung, recently reported, had progressed to the formation of pneumoliths in an apex cavity and their subsequent expectoration. Seventy small, hard, black angular stones were found at autopsy. They varied in shape and in size up to 7 mm. in diameter.

Rhinoliths are found in the nostrils after chronic inflammation of the mucous membrane; they are usually formed by the deposition of the nasal secretion about foreign bodies as a nucleus and contain a large proportion of organic matter.

Salivary concretions form in the salivary ducts, especially in Wharton's duct, and are usually oblong in shape. They are formed by the deposition of the salivary salts and may reach a large size; one weighing 7.5 gm. is recorded. They are composed chiefly of calcium carbonate and phosphate, mixed with epithelium and organic matter (Fig. 1478).

Tonsillar calculi, amygdaloliths, are sometimes formed in chronic enlargement of this organ in which the inspissated secretion of the crypts has accumulated deep within the gland and remained for a prolonged period of time, undergoing calcification. Fragments of the calculus may be discharged; in some instances the mass has been visible. The formation of a true tonsillar calculus is rare (Fig. 1479).

Urinary calculi are of frequent occurrence. They may be found in any part of the urinary tract, but usually occur in the pelvis of the kidney or in the bladder, and according to their location are designated renal or vesical. They occasionally occur in the kidney substance, in the ureters, or in the male urethra, and have been found in sinuses between the cavities of other organs and the urinary passages. Most varieties are formed by the deposit of normal or pathological urinary solids, and are usually named from the substances of which they are chiefly composed. Thus we designate the following: Uric acid, calcium oxalate, phosphate, urate, cystin, urostealith, calcium carbonate, and xanthin. The formation of concretions is not alone attributable to the mere separation of these substances from the urine, since instances are not uncommon in which copious deposits occur, particularly of urates, uric acid, oxalates, or phosphates, even for long periods of time, without the tendency to form calculi. Another accompanying condition is essential, namely, the presence of an albuminous substance which leads to an agglutination of the separating material in crystallization. Masses thus formed increase in size and become the various concretions with which we are familiar. Further evidence of the importance of this condition is obtained by dissolving out the salts of the calculus without macerating the mass, when an albuminous or colloid framework will remain. Hence we recognize two primary factors as being essential to calculus formation, namely: a tendency to the separation of certain urinary solids, and the presence of an albuminous substance in the urine which becomes the framework of the concretion (Figs. 1480–1485).

FIG. 1479.—Tonsillar Concretion. (Natural size.)

The former factor, that is, the tendency to crystallize,

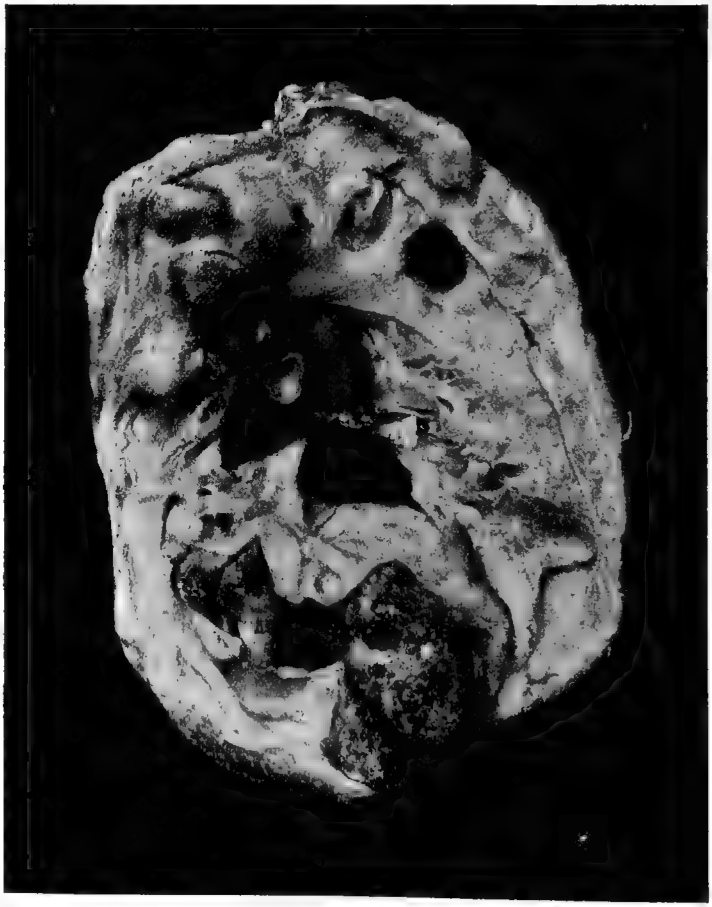

FIG. 1480.—Calculi in Kidney, Conforming in Shape to the Infundibular and Pelvic Cavities. (Natural size.)

is furnished by a considerable variety of urinary conditions, which will be mentioned in describing the constituents of calculi. The latter is dependent on a condition of renal or vesical irritation by means of which blood and serum, and perhaps undue amounts of mucus, are permitted to enter the urine. It reminds us, in a measure, of the condition essential to the formation of bilirubin-calcium, discussed in describing biliary calculi.

It is not to be understood that calculus formation is always accompanied by albuminuria. Such is not the case. Many instances are clearly recalled in which albuminuria was certainly not detected and probably did not exist. Vesical irritation, for example, introduces not necessarily serum albumin but always considerable mucus, the albuminoid basis of which is not known to us chemically, but which is probably a nucleo-proteid of some kind, not mucin as has been so generally stated. That urine contains mucus is a well-recognized fact and is proved by the formation of froth when the urine is shaken. This appears greater in concentrated specimens and in those which have remained long in the bladder. Under conditions of vesical irritation the mucus in urine is materially increased, and doubtless in some instances affords the factor which, as has been stated, is essential for conglomeration of crystallizing urinary solids.

Uric acid occurs in the body fluids and in urine in combination with sodium, potassium, or ammonium, the salt being, according to Roberts, a quadriurate.* He states that, if an aqueous solution of this salt be allowed to stand for some time, one-half the uric acid separates from the solution as crystals and the other half remains in solution in combination with the base as biurate. The quadriurate has split into uric acid and biurate. The reaction in urine differs somewhat from this. Acid phosphates are present and they react with any biurate formed and remove some of the base, at once converting the biurate again into quadriurate. Consequently biurate is never present in such quantity that it can be detected in the urine. The separation of uric acid from the remaining quadriurate and the conversion of the biurate into quadriurate again go on till ultimately no more quadriurate remains, when all of the uric acid will be deposited as crystals, excepting the small amount that is soluble as such in the urinary fluid. In urine the separation differs not only in the particular just mentioned, but also in that it is normally inhibited or greatly retarded. The water of the urine does not so readily break up the quadriurates as when in aqueous solution, the inhibition being chiefly due to the presence of the mineral salts or the pigment of the specimen. The separation of uric acid does go on, nevertheless, under certain pathological conditions in the manner that has been described. Just what the conditions are and just why they operate to effect the result it is difficult always to say, but we believe that at least four conditions tend to accelerate the precipitation—namely: (1) high acidity, (2) poverty in mineral salts, (3) low pigmentation, and (4) high percentage of uric acid, while the opposite conditions tend to retard precipitation.

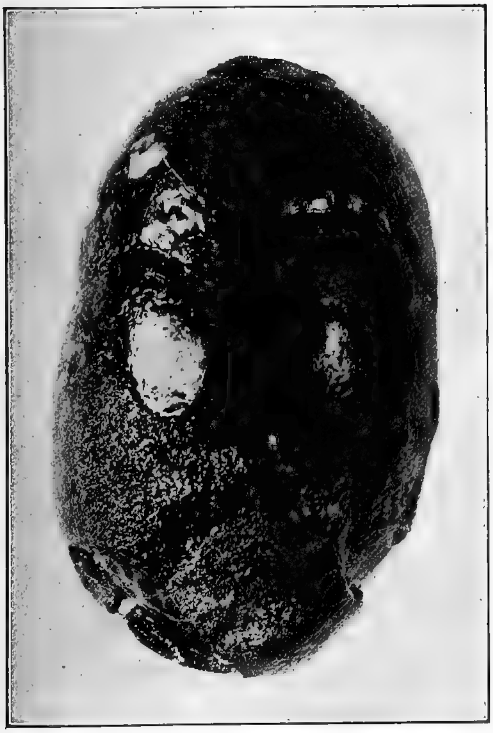

FIG. 1481.—A Stone from the Urinary Bladder. (Natural size.)

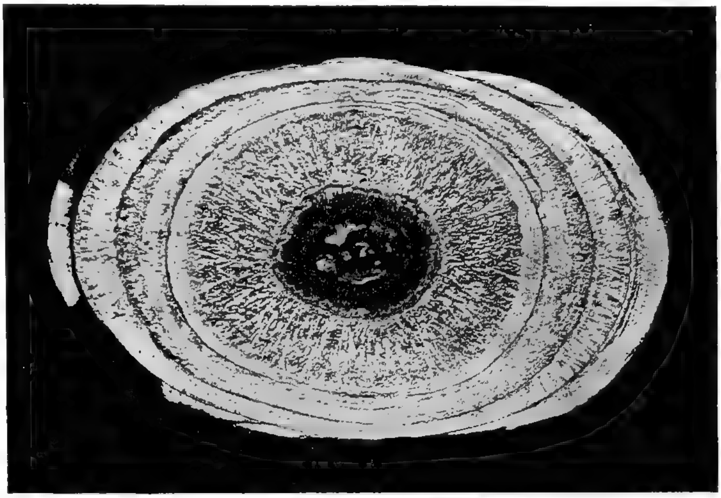

FIG. 1482.—Transverse Section of Fig. 1481. Showing the laminated body composed of magnesium phosphate and a nucleus of calcium oxalate.

The acidity of urine is due to acid phosphate, which in turn is derived from the basic phosphate of the blood. It may be increased by internal conditions, as, for example, the internal administration or production of acids or by a diminished secretion of acid in the gastric juice, under which conditions the increase is absolute; or it may be relatively increased by a diminution in the volume of water secreted. Acid is produced in prolonged muscular exertion, in diabetes mellitus, and by some of the putrefactive and fermentative changes that food may undergo in alimentation. A diminution in the volume of urine is noted in those who drink little water, in individuals leading a sedentary life, and in those who experience an increased loss of water from the body through other channels, *e.g.*, the sweat and bowels. Under these various conditions, then, urinary acidity and the consequent tendency to uric-acid separation are increased, and in the presence of the conditions of vesical or renal irritation already mentioned tend to the production of uric-acid concretions.

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* Tunnicliffe and Rosenheim have very recently attacked the conclusion of Roberts as to the existence of quadriurate, and state that it is a mixture of biurate and uric acid in varying proportions.

Under what conditions urine is poor in mineral salts we are not in every instance prepared to say. It is known that chlorides are diminished in various gastric disorders, and that in chronic interstitial nephritis the amount of phosphate in urine is below normal. Again, the increase of acidity by internal administration or production of acids may change the character, although it does not decrease the quantity, of the urinary salts.

The pigmentation of the urine is dependent on profound and at present not well-understood metabolic processes, and is derived more or less directly from the pigment of the blood, bile, and perhaps from the suprarenals. It is relatively low in dilute urine and in diabetes, and appears to suffer absolute reduction in other conditions which have not been carefully studied.

A high percentage of uric acid may be (*a*) relative, from the concentrated character of the urine, or (*b*) absolute, from its increased production in the body. The older view that uric acid originates from suboxidation of albuminous constituents of tissues is not supported by experimental or clinical evidence. It is now generally admitted that it is an end product of the destruction in the body of nucleins, either of body cells or perhaps of the food as well. Increase of uric acid, then, results (1) from the administration in undue amounts of nuclein in food, (2) from an increase of those physiological catabolic processes that result in nuclein decompositions, and (3) from pathological catabolic processes that accomplish this result. Uric acid in health appears to come chiefly from foods and from leucocyte destruction incident to the function of these migratory body cells, or at least it seems to be variation in these two sources in the great majority of instances that determines the usual variations in uric-acid excretion. This physiological process is augmented by those pathological states which bring about undue leucocyte activity, as, for example, many acute diseased conditions, leukæmia and certain other blood diseases, malignant growths, and auto-intoxications such as the digestive auto-intoxications that are frequently seen in neurasthenia. Pathological processes in which uric acid is formed from local cell necrosis appear to be the cause of the biurate production in various localities in gout. The urate passes into the blood and ultimately to the urine.

Of these four conditions leading to uric-acid separation, the acidity of urine is probably the most important factor. Uric acid is only slightly soluble in urine. With its continuous production in the body and with so many factors interacting to produce its separation from the urine, it is not surprising that the formation of concretions of this substance is more frequent than that of other forms of urinary stone. Uric-acid crystals have sharp edges and points, and thus tend to be more or less irritating, for which reason it appears that they are especially capable of giving rise to those conditions of irritation of the urinary tract by which the albuminous substances are introduced that we have seen to be essential to the aggregation of the crystallizing material.

Uric-acid calculi vary in size from a grain of sand to a goose egg. The surface is usually smooth, sometimes granular, while the color is yellow or red. They are moderately hard and may be quite irregular in shape, owing both to the shape of the cavity wherein they are contained and to the restricted attrition from motion. They originate in the pelvis of the kidney, but may pass to the bladder, usually causing the violent and paroxysmal pain of renal colic. In the latter cavity they may increase in size by the further accretion of uric acid, or they may enter into the formation of mixed calculi, mention of which will be made below. The formation of uric-acid calculi is most frequent in children and in the aged.

Urates are rarely the principal ingredients of urinary stone, such calculi being observed almost exclusively in children. The urate infarcts of the newly born may form true stones in the substance of the kidney, but most urate calculi are found in the pelvis or the lower part of the urinary tract. They are moderately soft, rarely large, and are grayish yellow in color.

Urates ordinarily separate from urine as a copious deposit, usually amorphous but occasionally crystalline, and are tinted a brick-red color by uroerythrin, their separation being dependent solely on their solubility and not on such a variety of conditions as we have seen to determine uric-acid precipitation. Consequently urate deposits are nearly always observed in concentrated urines. If the urates are increased by systemic conditions which have already been considered in connection with uric acid, the tendency to precipitation is thereby increased. Usually sodium is the base present, perhaps together with small amounts of potassium and ammonium, and even traces of calcium and magnesium. The ammonium salt is much more apt to deposit in urines which have undergone ammoniacal fermentation, separating as spheroidal clumps with projecting spines. The aggregation of the precipitating urates into calculi is apparently subject to the same conditions as determine the formation from other constituents.

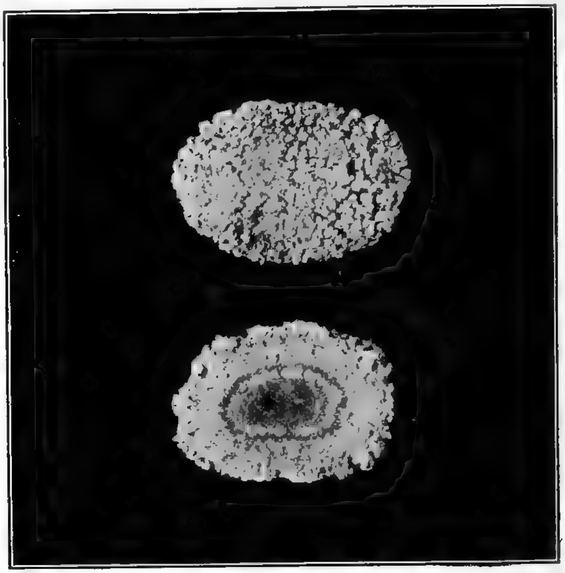
FIG. 1483. — Calculus of Calcium Oxalate. External view and section. (Natural size.)

Calcium oxalate forms the hardest of all urinary stones. They are rarely large, are more or less spheroidal in shape if single, facetted if multiple, and have either a rough, tuberculated surface, giving rise to the name of "mulberry" calculi, or less often they are small, rounded, smooth bodies known as "hempseed" calculi. They are usually dark brown or black, but may be light in color and may form in acid urine about a nucleus of epithelium or more commonly uric acid. Amorphous urates and phosphates may be deposited between the tuberculations. They have been found in the secreting substance of the kidney, but are usually formed in the pelvis, from which locality they may pass to the lower urinary tract. They probably never occur excepting in patients with oxaluria, a diathetic condition existing in certain neurotic states, particularly those associated with indigestion, and which, I believe, is always dependent on digestive disturbance. With the exception of the physiological oxaluria following the administration of oxalate in the food, it is probable that oxalic acid is formed in part or wholly from food in alimentation, chiefly from carbohydrates, by bacterial activity. Thus the administration of undue amounts of cane sugar is in certain individuals followed by the appearance of a copious deposit in the urine of crystals of calcium oxalate. It is further noticeable that such individuals are apt to suffer from hyperchlorhydria, an important connection when it is remembered that certain bacteria, including the colon bacillus, which tend to produce putrefaction of proteid matter in neutral or slightly acid media, direct their activities chiefly or wholly to the fermentation of carbohydrates in more strongly acid solutions.

Phosphatic concretions occur next in frequency to uric-acid calculi. They are composed of calcium phosphate, ammonio-magnesium phosphate, or both; are nearly always vesical in origin, and are usually formed in ammoniacal urine. For this reason they, together with other calculi dependent upon this urinary change for their formation, are spoken of as secondary concretions, in contradistinction to the primary calculi that separate in urine which has not undergone alkaline fermentation.

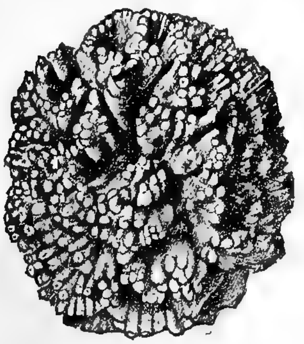
FIG. 1484.—Coral-Shaped Stone from the Bladder, Composed of Oxalate and Phosphate of Calcium. (Natural size.)

Phosphates are normal constituents of urine, in which they exist as soluble salts of the alkalies (about seventy-five per cent.) and salts of the alkali earths, calcium and magnesium; they are soluble only in acid urine. It is this latter portion that tends to separate, not, however, from the presence of an excess of phosphate or of calcium and magnesium, or from a concentrated condition of the urine, but owing to the absence of acidity of this fluid. In cystitis, for example, in which the urine is ammoniacal from decomposition, phosphates of the alkali earths are precipitated; and since this pathological state is so generally associated with vesical irritation, the condition is favorable to the agglutination of the separating phosphate into calculi. From what has been said it is apparent that the introduction of calcium into the body, as in the use of hard drinking-waters, can have no influence on the formation of these urinary concretions, as was at one time supposed to be the case.

The ammonio-magnesium salt, the so-called triple phosphate, is commoner in calculus formation than calcium phosphate, although calculi composed exclusively of the former are uncommon. Those occurring are not as a rule of marked size. Being formed in ammoniacal urine only, they are vesical in origin and frequently complicate cystitis.

Calcium phosphate only occasionally forms unmixed concretions. The structure of the latter may be compact or spongy. Two forms occur: 1. Round or oval, varying in size from a small bean to a hen's egg. They have a white, chalky appearance and break with an amorphous fracture. They are of vesical origin, and are more frequent in elderly people, especially dyspeptics. 2. Irregular, sometimes branched, usually of a grayish-white color, compact in texture, brittle, and with a porcelain-like fracture. They are usually found in cysts and pockets of the urinary tract and seem to be of local origin.

By far the most common phosphatic calculi are those of the mixed variety containing both calcium phosphate and triple phosphate; these calculi often attain a large size. Under the blowpipe they fuse to a black, enamel-like mass, and hence have been termed "fusible calculi." They have a grayish-white color, are friable and somewhat spongy, and are often composed of concentric laminæ. The outside and fracture surfaces may present bright, glistening points, triple phosphate crystals. They usually form about a nucleus of different composition.

Phosphatic calculi are exceptionally formed within the urethra, in which locality they are most frequently observed in infancy and after middle age. Their common seat is in the bulbo-membranous and prostatic regions and in the navicular fossa; they rarely form behind a stricture, but rather in urethral pouches and diverticula. The growth from incrustation is backward. As they increase in length they may be segmented by fracture, eventually forming a row of calculi that articulate with one another. There is usually a constriction at the vesical neck back of which the growth may extend in the bladder in any direction, the calculus eventually becoming mushroom-shaped or taking on the appearance of two nodules connected by a bar.

In pyonephrosis, in which ammoniacal fermentation of urine occurs in the pelvis, there is the same tendency to the formation of phosphatic calculi as when this change occurs, as it more commonly does, in the bladder.

Calcium carbonate calculi, which are so often found in other parts, are rarely found in the urine of man, but occur more frequently in herbivora. When found they have been multiple, small, weighing hardly more that 2 or 3 gm. each, with a smooth surface and resembling somewhat calcium oxalate stones, being hard and lamellar in structure. They are usually round, often translucent, and on section present numerous concentric lines and a multiple nucleus. On crushing they break into sharp fragments.

Cystin calculi occur but seldom. They are of primary formation, have a smooth or rough surface, are white or pale yellow, have a crystalline structure, and vary in size up to that of an egg. They are not very hard, but break with a crystalline fracture. On section they present a radiated surface of yellow color which turns gray on exposure to light. The occurrence of cystin is pathological. There appears to be a peculiar putrefaction within the intestine in cystinuria, leading to the formation of cadaverin and putrescin. Whether this is connected with the formation of cystin is uncertain but probable. During the formation of a cystin calculus, the characteristic hexagonal crystals of cystin are usually found in the urinary sediment. There appears to be a tendency to the formation of cystin calculi in members of the same family.

Indigo concretions have been met with in the urinary passage in one or two instances. The material for such a stone is derived, presumably, from the indican of the urine. This substance, which is indoxyl potassium sulphate, originates from indol, a product of the putrefaction of albuminous matter, usually in the intestines, and on oxidation readily yields indigo. In certain chronic diseased conditions within this organ it is continuously increased in the urine many times the usual amount.

Urostealith calculi consist of fatty matter in an amorphous or crystalline condition. Their occurrence is so exceedingly infrequent that their existence has been questioned: thus, Krukenburg found that what appeared to be a fatty concretion consisted in fact of paraffine derived from a paraffine bougie. That they do exist the writer is prepared to affirm from the fact that in a case in which one was passed he afterward found another at necropsy embedded in the tissue of the cystic kidney. Horbaczewski has recently analyzed one as follows:

Water	2.5 per cent.
Inorganic solids	0.8 "
Organic solids insoluble in ether	11.7 "
Organic solids soluble in ether	85.0* "

* 51.5 per cent. fat acids (stearic, palmitic), 33.5 per cent. neutral fat (myristic), trace of cholesterin.

At the temperature of the body these calculi are soft and elastic, for which reason they do not produce colicky pains when passing through the ureters. At ordinary temperature they are brittle, soft, have an amorphous or glassy fracture, and are translucent.

Xanthin calculi are exceedingly rare, less than a dozen being recorded in the literature. Their occurrence has been confined to young subjects. The calculi observed have been either pure, or mixed with uric acid, which xanthin so closely resembles. The size has varied from a pea to that of a hen's egg, and the color from whitish to dark brown. They have a medium hardness, amorphous fracture, and on rubbing take on a waxy appearance.

Calculi composed of *fibrin, blood*, or *inspissated albumin* are mentioned as having been met with in urine. They have a glassy fracture. Their occurrence must be regarded not only as unusual, but as anomalous.

In the description of the various urinary concretions very little has been said of the formation of mixed calculi. As a matter of fact, calculi are not commonly composed of a single constituent. The location of their formation and growth and the attending conditions upon which their formation depends so change from time to time that different substances enter into their structure, and the result is the formation of mixed calculi. Uric acid and calcium oxalate most frequently form calculi consisting exclusively of one ingredient; on the other hand, calculi composed of separate and alternating layers of these two substances are the most common example of the so-called "alternating" calculus.

The different deposits may be primary, primary and secondary, or secondary. They almost invariably have a central nucleus, while the substance of the calculus, the body, may be surrounded by an external layer or crust which is nearly always phosphatic. The nucleus varies in composition and in size. It may not differ from the body, especially in primary calculi, and on the other hand may even consist of bits of tissue, as blood clots, epithelium, or inspissated mucus. Exceptionally, foreign bodies which have found their way into the bladder become nuclei (Fig. 1485). A calculus was recently observed in which the nucleus was a snake's tail which a patient had been advised to pass into his urethra for the cure of a stiffened right arm. A form of mixed calculus that is very common is the phosphatic concretion that results from ammoniacal urine. A primary calculus, entering the bladder, or exceptionally forming within this organ, there produces such vesical irritation as eventually to give rise to cystitis with ammoniacal fermentation of the urine leading to the deposit of phosphate upon the primary formation.

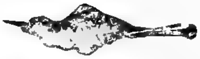

FIG. 1485.—Pin Forming the Nucleus of a Calculus Composed of Calcium Phosphate, Uric Acid, and Dried Blood. (Natural size.)

EXAMINATION OF URINARY CALCULI.—Before proceeding to the analysis it is always well to record the color, hardness, appearance on section or fracture, and perhaps the specific gravity of the specimen. The appearance of a powdered or fractured portion under the microscope may also be of value. In the case of mixed calculi, each layer should be examined independently. The chemical analysis may be conducted as follows:

Heat a small portion of the powder on porcelain or platinum.

A. The material burns away, leaving little or no residue.

1. It melts, burns with a smoky flame, emitting an aromatic odor. It is soluble in ether, the ether leaving a fatty residue on evaporation. It is soluble in potassium hydroxide. *Urostealith.*

2. It gives off purple-red vapor. The material is soluble in sulphuric acid with the formation of a blue color, the solution showing a band before D in the spectroscope. *Indigo.*

3. It gives the odor of burning feathers. The material responds to tests for proteids: *e.g.*, Millon's, xantho-protein. *Albumin, fibrin, blood.*

4. A fresh portion, when treated with hydrochloric acid, dissolves completely.

(*a*) Also soluble in ammonia. Filtration and evaporation to remove ammonia produce a separation of hexagonal crystals. These may also be obtained by acidifying the ammoniacal solution with acetic acid. *Cystin.*

(*b*) Dissolve a fresh portion in nitric acid, evaporate to dryness in a porcelain dish over a water bath, moisten yellow residue when cool with potassium hydroxide, and an orange-red color is produced which becomes reddish violet when heated. *Xanthin.*

5. A fresh portion, when treated with hydrochloric acid, does not dissolve completely. Filter and test the filtrate as described under 4.

(*c*) After washing the residue on the filter, dissolve in nitric acid and evaporate to dryness. The yellow residue turns red when exposed to the vapor of ammonia, and the addition of potassium hydroxide produces a bluish-violet color which disappears on standing. *Uric acid.*

(*d*) In addition to the test for uric acid, the fresh material gives reactions for ammonia, *e.g.*, when heated in solution with potassium hydroxide, ammonia fumes are given off as recognized by the smell, bluing of red litmus, and production of white fumes with a rod moistened with hydrochloric acid. *Ammonium urate.*

B. The material may or may not blacken and leaves a considerable residue.

6. The original material dissolves completely in hydrochloric acid.

(*e*) With effervescence. The solution made alkaline with ammonia yields a white precipitate on the addition of ammonium oxalate. *Calcium carbonate.*

(*f*) Without effervescence.

(1) The ignition residue, treated with water, dissolves in part to a strongly alkaline solution and dissolves wholly in acetic acid with effervescence. Addition of ammonium oxalate to this acetic-acid solution produces a white precipitate. *Calcium oxalate.*

(2) The ignition residue, treated with water, does not dissolve in part to a strongly alkaline solution. It dissolves in acetic acid without effervescence. If the nitric acid solution of the original material is added to an excess of ammonium molybdate solution in nitric acid a yellow precipitate is formed when the mixture is warmed. *Phosphate.*

The solution in acetic acid obtained above or of the original material yields a white precipitate on the addition of ammonium oxalate. *Calcium phosphate.*

The filtrate from the calcium oxalate yields a precipitate when rendered alkaline with ammonia. The original material, when moistened with potassium hydroxide, does not give reactions for ammonia. *Calcium and magnesium phosphate.*

The above reaction for ammonia is strongly positive and magnesium is present. *Ammonio-magnesium phosphate* (triple phosphate). If calcium is present as well there is an admixture of calcium phosphate.

7. The original material does not dissolve completely in hydrochloric acid.

Uric acid is present and may be tested for in the residue by the murexide test described in 5 (*c*). When a platinum wire is moistened with the hydrochloric acid solution and then introduced into a Bunsen flame, a yellow coloration of the flame is produced owing to the presence of sodium. *Sodium urate.* Traces of potassium urate and even the ammonium, calcium, or magnesium salt may be present.

(Note.—The application of the foregoing scheme to the analysis of mixed calculi may call for such slight modifications of the procedure as will be apparent.)

E. E. Smith.

CONDURANGO.—The bark of *Marsdenia Condurango* Nicholson, syn., *Gonolobus Condurango* Triana (fam. *Asclepiadaceæ*). This plant is a medium-sized, milky-juiced, woody twiner of Ecuador and neighboring parts of South America. The bark was introduced as a specific for cancer, due apparently to the loose application of this term, in South America, to various minor ailments. Its trial resulted in disappointment, notwithstanding that it produces some favorable results as an alterative, in cancerous as in other diseases. Besides containing a considerable amount of resin, *condurangin* has been described as an amorphous, yellowish glucoside. This is now believed to consist of a mixture of two or more glucosides, which are similar in action, producing incoordination and loss of movement. Their therapeutical application has not been demonstrated. They are soluble in both water and alcohol. Condurango is an excellent stomachic, though only mildly bitter. Weak alcohol is the best menstruum. The average dose is 2 gm. (gr. xxx.).

Henry H. Rusby.

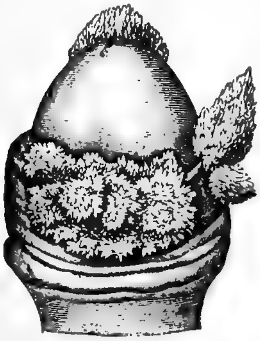

FIG. 1486.—Pointed Condylomata upon the Prepuce and Glans Penis. (After Grünfeld.)

CONDYLOMA.—Condyloma is defined by Unna as "a pure acanthoma, appearing isolated around the mucous openings and on moist and seborrhœic areas of skin, and tending to extend superficially." The word is here used in this limited sense, and indicates only those growths known as condyloma acuminatum. It thus becomes the name of a distinct pathological formation. The employment of the same word to designate certain syphilitic lesions (condyloma latum) is to be discouraged, except when it is properly qualified. The careful study of the histogenesis and histology of condylomata has demonstrated the incorrectness of employing papilloma as a synonym for condyloma. The formation is not a papilloma proper, the papillæ being secondarily altered by the proliferating epithelium. In the following description we have adhered quite closely to that given by Unna as representing the results of the most recent and reliable study. The growth begins as a small elevation, which later may become divided by furrows and depressions, giving when extreme a cauliflower appearance. They are usually located upon the external genitalia in either sex, or about the anus, and most often follow a chronic irritation from an inflammation of the urethra, ulcers, decomposition of the preputial secretion, etc. Bumm demonstrated that the previous idea that the gonococcus was the essential etiological agent was incorrect. He showed that they occur without gonococci being present. Kranz had apparently demonstrated the possibility of transferring portions of the lesion or its secretion with a subsequent development of condylomata at the site of introduction. This has been denied by Petters and Güntz, and they have been sustained by the experimental results of E. Bumm. Bumm found that long-continued chemical or mechanical irritation may cause the lesions, but insists upon the necessity of a predisposition being present also. If a specific agent is present, its nature is still unknown. The growth tends to extend locally by direct extension, especially in a serpiginous manner, following the folds where surfaces come in contact. In this way large tumor masses are produced, which show no tendency to become limited or to disappear spontaneously. The skin upon which they develop is usually previously altered by suppuration, eczema, seborrhœa, etc. The color depends upon the tissue where they are found during the early stage. Upon the skin they are yellowish-white, upon mucous membranes red. Later the degree of cornification determines the color, the red condyloma upon a mucous membrane becoming yellow.

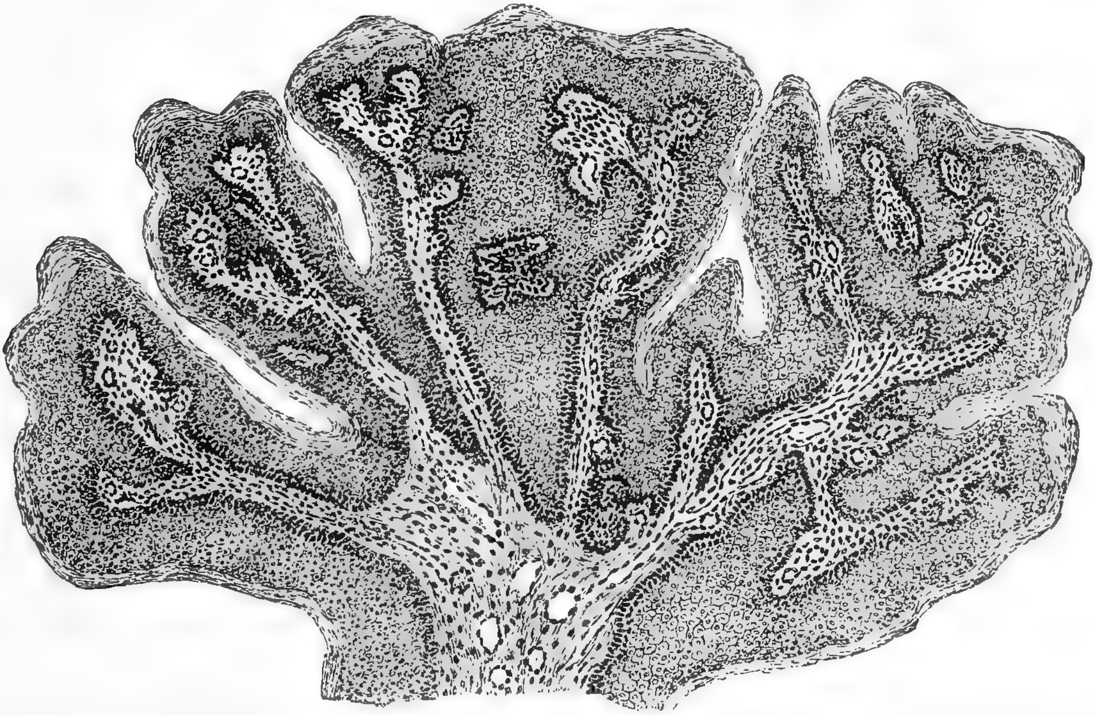

FIG. 1487.—Longitudinal Section of a Non-Specific Condyloma, Consisting of a Primary and Several Secondary Papillæ. The three layers—the horny, the epithelial, and the fibrous with its blood-vessels and lymph channels—are also represented. At the centre of the middle papilla and at the upper extremity of that to its right are seen transverse sections of the fibrous layer of tertiary papillæ arising from them. (From an original drawing by Dr. James M. French. Magnified about four hundred diameters and reduced.)

Unna distinguishes two histological stages. In the first there is a patchy thickening of the epithelium, with a depression and flattening of the underlying papillæ. There then becomes apparent, as a very fine point macroscopically, a button-like projection of epithelium. The growing epithelial ridges do not penetrate deeply nor depress the base of the papillary body, but they are rather elevated by the papillary body which becomes more and more swollen. The surface elevation is at first mostly dependent upon swelling of the cutis, but later the epithelium is greatly in excess. While the elevation and growth in size are due in part to changes in the connective tissue, the epithelium alone is active in the formation of the lesion. Differences in resistance at various points in the cutis are factors in determining the form of the growth, but this is only in a passive way. Many minute elevations occurring at the same time cause the surface to appear finely granular.

In the second stage the growth is either a cauliflower or finger-and-toe shape, or in the form of simple buttons. At this time the epithelium proliferates very luxuriantly, mitosis is found not only in the basal layer of the prickle cells, but even in the fourth, fifth, or sixth epithelial row. The prickle cells are much enlarged, some being four or even eight times the size of those in the neighborhood. There is great dilatation of the lymph spaces between the prickle cells, and the connecting bridges of the cells are unusually well developed. When the lymph spaces of the epithelium are very wide, the prickles connecting the epithelial cells may be drawn out to long threads, which may connect cells lying some distance apart and otherwise disconnected.

Everything indicates an exceptionally luxuriant nutrition of epithelium and a growth of the prickle layer in all directions from abnormally numerous points. The granular layer is broad, associated with delayed cornification. The horny layer is of normal thickness or only moderately thickened. There is no hyperkeratosis. The connective tissue is rich in blood and lymph, and penetrated by wide vessels and lymph spaces. The capillaries of the papillæ are sometimes as large as cutaneous veins and pass to the free ends of the papillæ. Nets of fibrin and fibrinous lumps with much granular fibrin are found in the wide lymph spaces, and the connective tissue is sometimes penetrated by fine fibrin threads. In the connective tissue there are found an excess of spindle cells, and an abnormal number of leucocytes, which wander into the epithelium. The action of caustics, etc., may be followed by a more extensive accumulation of leucocytes. Mast cells are always found in the newly formed connective tissue in considerable numbers, rather round in form than elongated, but large and multiform.

With the growth of the condyloma, the number of papillæ is always increasing. The original main papillæ, being abundantly supplied with blood and lymph, become considerably increased in size by the formation of young cells and the emigration of leucocytes. They also are divided by the ingrowing folds of epithelium, and thus the number of papillæ becomes increased. There is never, however, an independent growth of papillæ into the epithelium, as the name "papilloma" suggests. The irregular formation of condyloma is finally due to the succulence and marked swelling of the connective tissue and of the uncornified epithelium. The direction of growth is not limited, but is unlimited in all directions. The external form varies as widely as its internal structure. Rarely the horny layer is firm enough to form a continuous covering for the swelling, and a mushroom or pear-form results. More often the horny layer gives way, and after penetrating into the divisions between the larger main papillæ, it falls off, leaving the finger-and-toe form. If the horny covering of these again gives way, and the horny layer penetrates into the younger epithelial buds and between some of the newly furrowed papillæ, a cauliflower surface is the result.

Unna gives as the characteristics by which the condyloma may always be distinguished from verruca vulgaris as follows: "The thin horny covering and absence of hyperkeratosis; the remarkable size of the prickle cells and the interspinal spaces; the numerous and ever-present mitoses, even in the upper prickle layers; the complicated furrowing of the surface; the constant active dilatation of the vessels, which later gives place to a regular chronic inflammation, with cell formation, leucocytic emigration, and abundant sero-fibrinous exudation; and finally, the persistent papillary furrowing by the growing epithelium."

Treatment.—If the irritant acting upon the involved surface is removed, and the parts kept dry, or an astringent is applied, the smaller lesions may disappear without further treatment. The further means to employ for their removal are excision, erosion, or caustics (nitrate of silver, alkalies, acids, etc.). For larger growths, ligature of the pedicle may be required. Removal by the Paquelin cautery is followed by an eschar, which protects the surface and prevents hemorrhage. The electric needle is also useful at times. *George H. Weaver.*

CONIFERÆ.—*The Cone Family.* (*Pine Family*, in the broad sense. According to some authors, and probably correctly, it is subdivided into the *Pinaceæ* and *Taxaceæ*, but, for convenience, we here follow Engler and Prantl, in considering both under the title *Coniferæ.*) The family contains between thirty and forty living genera, and ten times as many species, besides a number of fossils. They grow mostly in temperate climes, especially the northern. Probably no other family is of greater interest. These trees represent a flora for the most part extinct, and are closely related to those which produced our coal. They are not so well adapted to present conditions as most plants, and their tenure of life may be regarded as on the whole weak, and themselves destined, for the most part, to early extinction. The largest known trees are members of this family. They yield almost all of our soft building lumber. They yield our vegetable tars, pitches, and turpentines, though apparently some of the trees yielding these will be practically extinct within a few years. Through extinct relatives, their relations to coal tar explain the close similarity between the two classes of products. The seeds of a number constitute important foods. Medicinally the family is of great importance, being very rich in volatile oils, of which those of juniper, cedar, turpentine, savin, cypress, and others, are important drugs. Empyreumatic oils similarly used are represented by those of tar and cade. Amaroids, glucosides, and at least one alkaloid, with an abundance of tannin, also occur. Because of the close similarity in nature and properties between these products, only the most important are treated in this work. The number of pines, spruces, firs, larches, cedars, and related plants in use is very great. *Henry H. Rusby.*

CONIUM.—Conium Fruit (incorrectly "*Seed*"). Hemlock. *Poison Hemlock.*

"The full-grown fruit of *Conium maculatum* L. (fam. *Umbelliferæ*) gathered while yet green" (U. S. P.). The leaves, formerly official, are no longer so. This plant is a stout, erect, biennial herb a metre or more (three to six feet) in height, with a long, simple or forked, rather fleshy, yellowish-white root 2 cm. or so in diameter, and a smooth, branching, striated or furrowed, purple-spotted, dark-green, hollow, slightly glaucous stem. The spots are small and rather numerous; the pith cavity is closed at the joints of the stem. The characters of the leaves and white flowers are well displayed in the accompanying cut.

Hemlock is a common Old-World plant, occurring in the temperate portions of Europe, Asia, and even Africa. It is also rather common in many places, as an introduced weed, in the United States. It affects rich and moist waste places, especially swamps and brook-sides and damp and shady gardens. It is easily distinguished from most harmless *Umbelliferæ* by its spotted stem, short, thick, disagreeable-smelling fruits, and the absence of oil-bearing vittæ in the latter. Cicuta (see *Poisonous Plants*) is very easily mistaken for it, but both are similarly poisonous.

Conium is notorious as an ingredient of the state poison of the ancient Greeks, by which the philosopher Socrates met his death. It is mentioned by several Greek writers of about the same time, and by numerous Latin ones since—by these often under the name *Cicuta.* It was used as a medicine by English and Scotch physicians several hundred years ago, but its employment under modern ideas of medicine dates from the time of Stoercke, about seventy-five years since. The use of the term *Cicuta* as the name of the hemlock by Latin authors has created some confusion, which was not diminished by Linnæus when he gave the latter name to the related genus.

All parts of hemlock are active, and have been employed in medicine. The drug should be carefully and quickly dried, without heat. As the active principles are volatile, conium deteriorates rapidly, and should be considered inferior if more than one season old. The intensity of odor developed by moistening it, and especially by treating with potash, is a rough way of estimating its value. The leaves are especially unstable; their odor, when fresh and green, is strong and disagreeable, and developed still more so by the potash; when dry they often have no strength or value. The fruits are alone official in the United States, the dried leaves having proved to be generally worthless in this country. They are thus described in the Pharmacopœia: "About one-eighth of an inch (3 mm.) long; broadly ovate; laterally compressed; grayish green; often divided into the two mericarps, each with five crenate ribs, without oil tubes, and containing a seed which is grooved on the face; odor and taste slight." They hold their strength comparatively well, and yield, on the whole, more uniform preparations than even the fresh leaves.

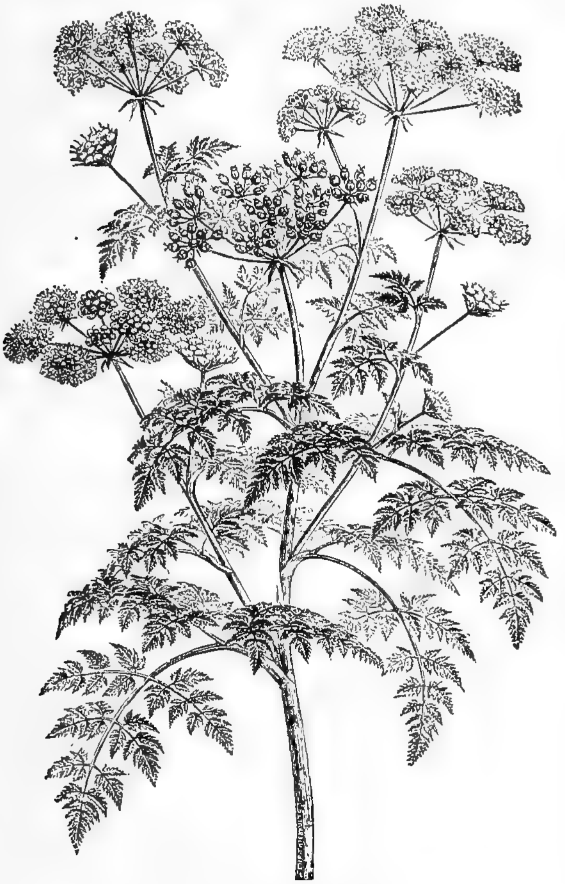

FIG. 1488.—Conium maculatum L.

COMPOSITION.—Conium contains but very little *essential oil* compared with the aromatic members of the order, and that little is neither pleasant nor useful. Its most important constituents are two or three closely related alkaloids.

The most important of these in quantity and activity is coniine, also called conicine and cicutine, which in the plant exists combined with one of the common vegetable acids, probably malic, to the extent of about one-fifth to one-half per cent. in the fruit. The leaves contain much less. It is a strongly basic, colorless, oily liquid, of penetrating odor, closely resembling that of urine or the nests of mice, and a sharp, burning, tobacco-like taste. It is volatile at ordinary temperatures, and boils at 166° to 166.5° C. *In vacuo* it can be redistilled without change, but in the air a portion is decomposed. It becomes thicker and yellow upon prolonged exposure, and, finally, resinous looking. Specific gravity, 0.88. Chemical composition, C_5H_9,NH,CH_2,CH_2,CH_3. It is freely soluble in alcohol, chloroform, the essential oils, etc., but only to the extent of one per cent. in water. It, on the other hand, dissolves in from twenty to thirty per cent. of cold water, which may be separated by heating. It unites with acids, forming neutral salts, which are often crystallizable. That most used is the hydrobromate, in white needles, soluble in two parts of water or of alcohol. Complete purification of coniine is difficult to accomplish.

The second alkaloid, *conhydrine* or oxyconiine, is solid and concretes in the head and tube of the retort in pearly, iridescent, white, foliaceous crystals. It has a faint, conium-like odor, melts at 118° to 121° C., and boils at 220° to 225° C. It is soluble in alcohol and slightly so in water. Conhydrine can be converted into coniine by abstracting the elements of water with phosphoric anhydride. The proportion of conhydrine in conium is much less than that of coniine. Methyl coniine is usually present in commercial coniine and is probably a constituent of the drug itself. The coniine of the market is also apt to contain some pseudo-conhydrine dissolved in it, which can be separated by freezing. This is white, crystalline, soluble in alcohol and water.

The physical properties of coniine and conhydrine are very nearly those of an essential oil and its camphor.

ACTION AND USE.—The action of conium may be regarded as entirely that of coniine; conhydrine and methyl conine, besides their smaller proportion, are physiologically only coniine reduced; the oil and other constituents (vegetable acids, etc.) amount to nothing.

It is very difficult to interpret and harmonize the phenomena attending the action of coniine. Pharmacologists are not agreed as to the mode of their production, and they will be considered here only in their practical bearing. The drug is promptly absorbed from the stomach, very slightly if at all locally, circulates as coniine, and is rapidly excreted through the kidney. It is a nauseating depressant, the effect varying in degree from slight languor and weakness, through nausea, salivation, weak perspiration, vomiting, great muscular weakness, results in general similar to sea-sickness, up to complete collapse and death by respiratory failure, after preliminary stimulation. There is dilatation of the pupil, perhaps after temporary contraction, especially upon local application. There are evidences of vaso-motor depression. There is slight depression of the cardiac ganglia. There may be temporary and slight tremors and muscular twitchings, though the later, and strictly speaking physiological effect is opposed to these, destroying them when they already exist. There is little disturbance of sensation proper, and intelligence is little or not at all affected. The one important element is depression, or paralysis of the motor nerve endings. There is apparently, at first, central stimulation, followed by depression, beginning below and passing upward. The peripheral paralysis referred to also apparently proceeds gradually along the nerve trunks. The best authorities agree that conium has failed in nearly all the therapeutic uses to which it has been put. Most of these uses have centred about the theory that it relieves pain, in spite of its failure to affect sensory nerves. The fact is that when pain is kept up through muscular twitchings, commonly themselves induced by existing pain, conium prevents this aggravation by cutting these movements short. In any case, this appears the only use for which it can be recommended.

In administering conium, it is most important that the nature of its constituents be remembered. Coniine, the most important, is volatile, so that careless manufacture is destructive to activity. Long exposure to the air also induces destructive changes. The greatest care should thus be taken in selecting preparations, and only those which are assayed should be accepted. Conium and its fluid extract should contain 0.5 per cent. of total alkaloid, the extract 2.5 per cent. The Pharmacopœia supplies an extract, the dose of which is 0.02–0.06 gm. (gr. $\frac{1}{4}$–i.), and a fluid extract, the dose ♏ i.–v.

Henry H. Rusby.

CONIUM, POISONING BY.

See *Hemlock*.

CONJUNCTIVA, AFFECTIONS OF THE.

—Hyperæmia of the Conjunctiva.—Hyperæmia of the conjunctiva, when at all pronounced, is apt to be accompanied by more or less discomfort of the eyes—usually a sensation of burning or itching—and by undue lachrymation. It is met with as a transient condition and also as a chronic and persistent one.

Transient or acute conjunctival hyperæmia may arise from a great variety of causes and, as a rule, is a matter of but little moment. The presence of a foreign body upon the cornea or conjunctiva, exposure of the eyes to a strong wind, to undue heat or intense light, prolonged use of the eyes, especially with imperfect illumination, crying, irritant gases, etc., are some of the causes which may give rise to it. It also marks the onset of most superficial inflammations of the eyes, and is a frequent accompaniment of acute rhinitis and of facial neuralgia.

Chronic conjunctival hyperæmia, a condition of greater significance, is probably more frequently due to eye strain, the result of errors of refraction or anomalies of the ocular muscles, than to any other one cause. It may also be dependent upon chronic rhinitis, inflammation of the lachrymal passages, trichiasis, alcoholism, and gout.

In the treatment of this condition the most important consideration is the removal of the cause. In chronic hyperæmia the refraction and muscular balance of the eyes should be looked into, and, if they are found to be indicated, glasses should be carefully adjusted. Nasal or lachrymal disease, if present, should be treated, and measures taken to combat any disorder of the system, such as a gouty diathesis, which might be a factor in the causation of the local affection. As supplementary measures, a collyrium of boric acid (2 to 100), or of boric acid (2 to 100) and sulphate of zinc ($\frac{1}{20}$–$\frac{1}{10}$ to 100) and, especially in acute cases, the application to the lids of cold water or ice cloths, are useful.

Conjunctivitis.

Although authors given to multiplying titles describe many kinds of conjunctivitis, there seems to be no good reason for making more than eight distinct varieties, namely: (1) Catarrhal or simple conjunctivitis; (2) purulent conjunctivitis; (3) croupous or membranous conjunctivitis; (4) diphtheritic conjunctivitis; (5) follicular conjunctivitis; (6) trachomatous or granular conjunctivitis; (7) vernal conjunctivitis or spring catarrh; and (8) phlyctenular or scrofulous conjunctivitis. Whether regarded from a clinical or a pathological point of view, all of the usually described forms of conjunctival inflammation may very properly, and with practical advantage, be divided into these eight varieties, which, though they possess certain features in common, exhibit other well-marked and distinctive characteristics. As a rule it is not difficult in practice to differentiate these several varieties; but occasionally the most experienced observer may find himself at fault in this respect, being unable to determine, simply from inspection, to which class a particular case should be assigned. The history of the case, and especially its behavior under treatment, will, however, dispel the doubt. With the exception of diphtheritic and phlyctenular conjunctivitis, all of these different varieties of conjunctival inflammation are essentially local disorders. As regards their etiology much has yet to be learned, though considerable progress has been made in this direction within the past few years. Catarrhal conjunctivitis undoubtedly arises from a variety of causes. It may, like catarrh of the nasal or bronchial mucous membrane, be produced by exposure of the surface of the body to cold, and is then doubtless dependent directly upon vasomotor disturbance; or it may be excited by irritant vapors or other substances coming in contact with, and acting immediately upon, the conjunctiva. There is also a variety which is decidedly contagious, and which under favorable conditions spreads from individual to individual, direct contact or transference of secretion from one eye to another not being necessary to its propagation. Here, doubtless, there is a volatile specific germ which finds in the conjunctival sac conditions especially favorable to its development, and which during its sojourn there excites in this membrane, in much the same fashion that the irritant vapor does, first a hyperæmic, and then an inflammatory condition. According to Weeks, the micro-organism which gives rise to this variety of conjunctivitis is a small bacillus, resembling that of mouse septicæmia, which stains readily with methylene blue and loses its color by the Gram method. Other investigators, however, have been led to regard the pneumococcus as the active agent. Purulent conjunctivitis, on the other hand, which rarely occurs, in this country at least, except in the new-born from infecting vaginal discharges, and in adults from gonorrhœal inoculation, is (in these forms at any rate) essentially a specific germ disease; and, fortunately for the human race, the micro-organism—the gonococcus—which gives rise to it, is non-volatile, and, therefore, communicable only by gross transplantation and not through the medium of the atmosphere.

A priori, there is no reason why a purulent conjunctivitis should not be produced otherwise than through the agency of the gonococcus, and probably under certain conditions of climate, etc. (as in Egypt), this may happen; but, under the relatively favorable hygienic conditions which prevail in this country, it may be safely asserted that a conjunctival inflammation of such intensity as to warrant its being classed as purulent, scarcely ever occurs except as the result of gonorrhœal inoculation.*

Trachomatous or granular conjunctivitis is also doubtless the product of a specific germ. It is decidedly contagious, but, like purulent conjunctivitis, is communicated only by direct transference of discharge from eye to eye. A small diplococcus, isolated by Sattler, is supposed to be the contagium which gives rise to it, but this has not been definitely proven.

Diphtheritic conjunctivitis is, of course, due to the presence in the conjunctival sac of the Klebs-Löffler bacillus; but, as the ocular mucous membrane does not seem to be a favorite habitat for this organism, it is a disease of rare occurrence.

As to the etiology of croupous conjunctivitis and of vernal catarrh, we are yet without definite knowledge; that of phlyctenular conjunctivitis will be considered later.

Having said this much regarding the specific characteristics of the several varieties of conjunctival inflammation, we shall take up separately each variety for more particular consideration, and, having in mind the practical purpose of this article, shall deal with them from a therapeutical rather than from a pathological standpoint.

Catarrhal Conjunctivitis.—In a well-marked attack of this disease, decided evidences of ciliary irritation are present. Pain is rarely felt, but, especially at the commencement of the attack, there are photophobia and more or less profuse lachrymation. A sensation as though a foreign body were in the eye is almost always complained of; and, as at this stage of the disease the symptoms, including the commencing conjunctival injection and the slight mucous discharge, are precisely such as are produced by the presence of a foreign body, it is always best, by careful inspection, to make certain that they are not due to this cause. The cornea, therefore, should be carefully scanned, and the lids everted and their conjunctival surface scrutinized, so that the presence of a foreign body may not be overlooked. Although catarrhal conjunctivitis almost invariably affects both eyes (differing in this respect from phlyctenular, and to a still more pronounced degree from purulent conjunctivitis), it sometimes begins twenty-four or thirty-six hours sooner in one than in the other. When, already, both are affected there is, of course, small reason to suspect the presence of a foreign body. In mild cases the inflammation is limited to the palpebral conjunctiva and the discharge is slight and mucoid in character, gumming the lids together during sleep, but during the day showing itself only about the inner canthus and in the retrotarsal folds of the conjunctiva; in severe cases there is marked injection of the bulbar conjunctiva, and the discharge is more profuse and is muco-purulent in character. The injected vessels are comparatively coarse, are tortuous and movable, and cause the bulbar conjunctiva to have a uniform brick-red color, in marked contrast to the pinkish, pericorneal injection, due to hyperæmia of the finer and immovable subconjunctival vessels, which is characteristic of corneal and iritic inflammation.

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* The writer does not recall a single case of well-marked purulent conjunctivitis met with, in either hospital or private practice, during an experience of nearly thirty years, which could not be traced either to some similar case or to inoculation with a vaginal or urethral discharge.

Epidemics of catarrhal conjunctivitis not infrequently occur in orphan asylums and in other institutions where large numbers of children are brought together. Under such circumstances it is apt to be more severe in type (closely resembling, in some instances, trachomatous conjunctivitis) and less amenable to treatment. Especially in strumous children, a conjunctivitis purely catarrhal at the outset, and due, perhaps, to cold or contagion, may assume a phlyctenular type, and, secondarily, the cornea may become involved. The use of unduly strong astringent collyria tends to bring about this unfavorable change.

Catarrhal conjunctivitis rarely assumes a chronic form, except through the operation of special causes. In obstinate cases, therefore, complicating conditions must be sought for, and, if possible, eliminated. Sometimes it will be found that the conjunctival inflammation is only a secondary manifestation of a chronic naso-pharyngeal catarrh, or there may be stricture of the nasal duct present, with blennorrhœa of the lachrymal sac. In other instances the strain due to optical errors may prolong the attack, or even excite a mild form of conjunctivitis. Extraneous causes, such as the presence of irritant gases in the atmosphere (as in the neighborhood of certain manufacturing establishments), also have their effect, rendering of no avail remedial measures which otherwise would prove effectual.

The *treatment* of this variety of conjunctivitis can be described in a few words. The most important point to bear in mind is, that harsh remedies are to be avoided, as they are likely to do harm by producing corneal complications, and so converting a very simple into a possibly serious condition. When there is considerable ciliary irritation at the commencement of the attack, decided relief may be obtained by applying to the closed lids, more or less constantly, linen or absorbent gauze pads wet with a lotion of boric acid and opium (ext. opii, 0.60 gm.; boric acid, 3 gm.; aq. destill., 128 gm.; or ext. opii, gr. x.; boric acid, gr. xl.; aq. destill., ℥ iv.)—a most useful preparation in many conditions of the eyes attended by ciliary irritation. As a collyrium the writer has found nothing so generally efficacious as a 2 to 100 solution of boric acid, with the addition of a small quantity of sulphate of zinc, the proportion of the latter being varied, according to the amount and character of the discharge and the sensibility of the eye, from $\frac{1}{20}$ to 100 to $\frac{1}{5}$ to 100 (zinci sulphat., gr. $\frac{1}{4}$–i.; acid. boric., gr. x.; aq. destill., ℥ i.). By means of an eye-dropper this should be applied to the eyes freely three times a day, the head being held back, and the solution kept in contact with the eye for some moments. In addition, a simple ointment such as cold cream or vaselin cerate,* should be applied to the edges of the eyelids at bedtime, to prevent their being gummed together by the drying of the discharge during the night.

Under this treatment the inflammation usually begins to subside within a day or two, and at the end of a week or ten days will have entirely disappeared. When a satisfactory improvement does not manifest itself, some other astringent should be substituted for the sulphate of zinc. Alum and nitrate of silver are both useful, the former in the proportion of gr. ij.–v to ℥ i., the latter in much weaker solution—gr. $\frac{1}{8}$–$\frac{1}{2}$ to ℥ i. Tannin (gr. iv.–viij. to ℥ i.) is a favorite remedy with some, while protargol, in from 5 to 100 to 10 to 100 solution, has recently been highly commended. When there is doubt as to the character of the inflammation—whether it be simply catarrhal or phlyctenular—boric acid in a fairly strong solution is the safest thing to prescribe, as it is likely to do good in either case and certainly can do no harm. In obstinate cases the probable existence of complicating conditions is to be borne in mind, and if found to be present, these, of course, should receive the attention they may require. Should the inflammation assume a phlyctenular character the use of astringents ought to be discontinued at once, and in their stead the remedies employed which are suited to this form of conjunctivitis.

After a severe attack of catarrhal conjunctivitis, especially if its treatment has been neglected, the eyes sometimes remain asthenopic and irritable for a considerable time. When this occurs they should be given as perfect rest as practicable, the state of the patient's health, which commonly needs building up, should be looked after, and soothing local remedies, such as the boric acid and opium lotion referred to above, or a collyrium of boric acid (2 to 100) should be employed.

Purulent Conjunctivitis.—Although it is possible, as has been said, for a conjunctival inflammation of such intensity as to deserve the name purulent to be excited in a variety of ways, practically, a pronounced purulent conjunctivitis hardly ever occurs, at least in this country, except as the result of gonorrhœal inoculation.

In the severer types of catarrhal conjunctivitis the discharge, as has been stated, frequently assumes a muco-purulent character, and also in some cases of scrofulous conjunctivitis this may happen; but these are not cases of true purulent conjunctivitis, and should not be described, as they sometimes are, as such. In purulent conjunctivitis the inflammation, though similar in character, is far more intense than in the catarrhal form. The discharge, which is very profuse, is thick and creamy, and, since the inflammation is not confined to the conjunctiva but involves the submucous tissue, the lids become greatly swollen and tense, so that it is commonly impossible to evert them, and the loose texture covering the anterior segment of the ball so œdematous and chemotic that it overlaps and nearly hides from view the cornea. In consequence of this the nourishment of the cornea is seriously interfered with, and ulceration and necrosis frequently occur, and may lead to its complete destruction. The prognosis is more grave, and the inflammation usually runs a more violent course, in the gonorrhœal conjunctivitis of adults than in the infantile form of the disease. Why this should be is not plain, since both are due to specific inoculation, and in the discharge from each the gonococcus of Neisser is present. Probably, as has been suggested, the explanation is to be found in the fact that the discharge which infects the eyes of infants is seldom the product of a recently acquired gonorrhœa, whereas in adults the inoculation is more apt to occur during the height of the urethritis or vaginitis, when the infecting power of the discharge is greatest. It would seem, however, apart from this, that the eyes of the new-born are capable of resisting the disease better than are those of adults. From twelve to forty-eight hours is given as the interval which usually elapses between the inoculation of the eye and the outbreak of the disease (Nettleship); but in infants the interval is not so brief, since the inflammation of the eyes does not manifest itself, as a rule, until the third or fourth day after birth. In ophthalmia neonatorum both eyes are usually affected, because each is almost sure to be inoculated with the vaginal secretion; in adults the disease begins in one eye, and only spreads to the other if there is an actual transference of the discharge. In the beginning of the attack there are considerable photophobia and lachrymation, with a sensation as though sand were in the eye. Later on, the irritation of the ciliary nerves is so great as to cause severe pain, which

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*Yellow wax, one part; vaseline, four parts: melted together and stirred while cooling.—*Vide* Trans. Am. Ophthalmological Soc., vol. iii., p. 572.

may become intense if perforation of the cornea occurs with prolapse of the iris and secondary iritic inflammation. At first the discharge is not purulent, but mucoid or thin and watery in character. This usually gives place very soon to a true purulent discharge, which is thick, yellowish, and very abundant. In some cases this change is slow in manifesting itself, and under such circumstances the inflammation is apt to be more intense, and the appearance of the purulent secretion may be preceded by a plastic infiltration of the subconjunctival tissue, and a membranous exudation upon the surface of the conjunctiva. After this severe type of the disease cicatricial bands, like those which occur in the submucous tissue of the urethra and give rise to stricture, may form in the conjunctiva and in the cellular tissue beneath it, and by their contraction may cause distortion or incurvation of the lids. Opacities of the cornea, varying in extent and density, due to ulceration, with in many instances anterior adhesions of the iris, are among the frequent consequences of purulent conjunctivitis.

Besides the true purulent form of ophthalmia neonatorum, which outside of lying-in asylums is comparatively a rare disease, there is a mild variety of conjunctivitis, very amenable to treatment, which is frequently met with in the new-born. It is characterized by slight swelling of the lids, considerable conjunctival injection, and a mucoid discharge sufficient in amount to gum together the lashes. It yields very promptly to the instillation, three or four times a day, of a 2 to 100 solution of boric acid, and as we can never be certain when we encounter this mild form of conjunctivitis that it is not the incipient stage of the more severe ophthalmia, its treatment should in no case be neglected.

Exceptionally, this mild type of conjunctivitis in the new-born does not respond so satisfactorily to treatment, and then it will usually be found that it is associated with and dependent upon a blennorrhœa of the lachrymal sac. A collyrium of bichloride of mercury (1 to 12,000), to be dropped into the inner corner of the eye, after the lachrymal sac has been emptied of its contents by gentle pressure with the tip of the finger, is the remedy the writer has found most useful in controlling this condition, which, in his experience, rarely requires operative treatment. Alum and boric acid, and nitrate of silver (1 to 2,000) are also useful.

In gonorrhœal ophthalmia the prognosis is extremely grave, destruction of the cornea being of frequent occurrence. When this destruction is not complete, however, the ultimate result as regards vision is far better than would seem possible during the height of the inflammation, the portions of the cornea not destroyed clearing up in a surprising manner. The disease runs a tedious course, and, even when the cornea escapes, the conjunctival inflammation may not disappear entirely for two or three months. After the more acute symptoms have subsided, a "granular" condition of the palpebral conjunctiva, which closely resembles true trachoma, but should not be confounded with it, as it is less obstinate and more amenable to treatment, frequently makes its appearance.

In the *treatment* of purulent conjunctivitis time is a most important element. If seen at its very commencement, it is possible, by active measures, to cut short even a case of genuine gonorrhœal ophthalmia. The writer's experience furnishes at least one unquestionable example of this. The success which has attended the prophylactic measures recommended by Credé, for the prevention of ophthalmia neonatorum, shows what may be accomplished in this disease by treating the eye immediately after the inoculation has occurred, and before inflammation has had time to develop. Credé's plan is to drop into the eyes of all children, directly after birth, when there is reason to fear inoculation, a 2 to 100 solution of nitrate of silver. In the large lying-in hospitals of Europe, where this plan has been extensively adopted, every child being treated in this way, the results have been extremely satisfactory, the percentage of ophthalmia neonatorum, heretofore so large as to be a matter of serious moment, having been reduced to a small fraction of what it formerly was; and, as the instillation of such a solution into the eyes of the new-born seems to be attended by no unpleasant consequences, this prophylactic measure should never be neglected when there is the slightest reason to fear that inoculation has occurred.

The abortive treatment of gonorrhœal conjunctivitis, which has been practised for many years, is practically the same as that suggested by Credé for ophthalmia neonatorum. It consists in the daily application to the everted lids, at the earliest possible moment after the disease has begun to manifest itself, of a strong solution of nitrate of silver (from 2 to 100 to 4 to 100). When there is reason to suspect that there has been a transference of specific matter to the eye, the risk involved is so great as to justify resort to this treatment without waiting for the supervention of conjunctivitis, especially as the pain which the application of the silver solution produces may be obviated entirely by instilling into the eye, beforehand, a few drops of a 4 to 100 solution of muriate of cocaine, or better still, perhaps, of a 1 to 100 solution of muriate of holocaine. When, however, the disease has once become fairly established, we can no longer expect to cut it short. Our efforts, then, must be directed to controlling, as far as possible, the intensity of the conjunctival inflammation, and preserving the integrity of the cornea.

Although various remedies have from time to time been recommended as especially efficacious in the treatment of purulent conjunctivitis, there is not one which has proven so generally useful as nitrate of silver. The daily application (to the everted lids, if the swelling is not too great to prevent their being turned out) of a strong solution of nitrate of silver (from 2 to 100 to 4 to 100, according to the condition of the cornea and the sensitiveness of the eye), anæsthesia having been induced beforehand by a 1 to 100 solution of holocaine; the instillation two or three times a day of a $\frac{1}{5}$ to 100 to $\frac{3}{5}$ to 100 solution (gr. i.–iij. to ℥ i.) of nitrate of silver; the application, in a similar manner, of a 1 to 100 solution of sulphate of atropine, to diminish pain and to obviate, or favorably influence, corneal complications, together with the more or less constant application of ice-cloths to the lids, if grateful to the patient, or, if more acceptable to him, of cloths wet with a lotion of opium or belladonna (ext. opii vel ext. belladonnæ, 2 gm. (gr. xxx.); aquæ, 256 gm. (fl. ℥ viij.), and the careful cleansing of the eye every hour, or even every half-hour, while the discharge is profuse and creamy, with a saturated (4 to 100) solution of boric acid, constitute a plan of treatment which, in the gonorrhœal ophthalmia of adults (the most virulent form of purulent conjunctivitis), offers the best prospect of success, and which, with slight modification, generally is successful in the infantile form of the disease. When ulceration of the cornea is present, the stronger solutions of nitrate of silver are not so well borne, and must be used with more caution, being applied, if practicable, only to the palpebral conjunctiva, and not allowed to come in contact with the cornea; or the silver solution may be neutralized by applying directly after it a warm solution of table salt. When there is pronounced chemosis, scarification of the conjunctiva does good by depleting somewhat the distended vessels; and when the swollen lids appear to be exerting dangerous pressure upon the eye, free division of the outer canthus (a single cut with strong, straight scissors, in a horizontal direction, will suffice) is recommended, and is doubtless a judicious procedure, although the writer's experience has not presented a case in which resort to it seemed to be called for.

Protargol, in from 20 to 100 to 40 to 100 solution, has of late been recommended as a useful substitute for nitrate of silver, its chief advantage being that its application causes but little discomfort. Several cases of ophthalmia neonatorum, recently under the writer's care, have yielded in an exceptionally favorable manner to protargol, supplemented by hourly cleansing of the eyes with a saturated solution of boric acid. A 10 to 100 to 20 to 100 solution of protargol was dropped into the eyes three times a day, and a 40 to 100 solution (which seemingly caused but little discomfort) was applied to the everted lids every other day.

As the transference of pus from the inflamed eye to the sound one will almost inevitably cause the disease to develop in it, every precaution should be taken to prevent this happening. The patient and attendants should be constantly warned of the danger of handling the sound eye when there is a possibility of the discharge being on their fingers, and of the risk of inoculating this eye while cleansing and applying remedies to the diseased one. To lessen this latter risk, as well as to diminish the danger of the attendant's eyes being inoculated, the writer would suggest that the discharge be removed by means of absorbent cotton, and not, as is usually recommended, with a syringe. While the discharge is abundant the patient should not be allowed to lie with the diseased eye uppermost, as in this position the pus may flow across the bridge of the nose, and so reach the opposite eye. The frequent washing away of the discharge with the boric-acid solution, as already suggested, will further lessen the likelihood of this accident occurring. Most authorities recommend that the sound eye be hermetically sealed up with rubber adhesive plaster and collodion; and, to render this more endurable to the patient, Dr. Buller, of Montreal, inserts a watch glass between two layers of the rubber plaster, so that the eye may still be used, and leaves the outer and lower angle of the covering open for ventilation.

As the intensity of the inflammation subsides, and especially as the discharge diminishes and loses its creamy consistence, becoming muco-purulent in character, the treatment should be less active, the astringent and antiseptic applications being made at longer intervals, and the strong silver solution diminished in strength or tentatively omitted. It is in this way only—by carefully watching the effect of the remedies employed, and by modifying the treatment from time to time as may seem necessary—that the inflammation can be kept in some measure under control, and the great danger which constantly impends, destruction of the cornea, be obviated. Besides the remedies which have been mentioned, others, such as corrosive sublimate in weak solution ($\frac{1}{20}$ to 100), carbolic acid (5 to 100), finely powdered iodoform, to be applied freely to the conjunctiva, peroxide of hydrogen, and weak solutions of permanganate of potassium, trikresol, and formaldehyde, have been recommended as useful in this disease.

In the so-called diphtheritic form of purulent conjunctivitis, in which the discharge is thin and ichorous, and there is a tendency to plastic exudation and infiltration, strong astringent solutions are contraindicated. Boric acid and atropine should here be chiefly relied upon, until by the application of warm fomentations the type of inflammation shall have been changed, and the discharge shall have assumed a purulent character, when the use of protargol or nitrate of silver should be begun with caution and the effect carefully noted.

Constitutional treatment may not be called for in all cases, but when the patient is in robust health and of plethoric habit, the good old plan of moving the bowels freely by a mercurial purgative will do good; while, on the other hand, quinine should be given freely, supplemented by iron and a generous diet, when there is anæmia and an impoverished state of the system. After the acute symptoms have subsided, alum and tannin are especially useful in overcoming the persistent hyperæmia of the ocular, and the so-called "granular" condition of the palpebral, conjunctiva.

The treatment of purulent conjunctivitis in the infant is essentially the same as in the adult, except that, as the inflammation is generally less intense, the caustic and astringent solutions should be somewhat milder, ice-cloths are not indicated, and the opium and belladonna fomentations are, of course, out of place. The instillation of atropine, however, should not be omitted, especially if ulceration of the cornea be present or threatening. Chiefly from maltreatment or neglect, this affection probably causes a greater amount of irremediable blindness than any other one disease of the eyes. When the destruction of the cornea has not been complete, however, it frequently happens that great improvement in vision may be obtained by a well-placed artificial pupil.

CROUPOUS OR MEMBRANOUS CONJUNCTIVITIS.—It is with some hesitation that I describe this variety of conjunctival inflammation as a separate disease, since there are excellent reasons for regarding it rather as simply a type of inflammation prone to occur, under favoring conditions, in several different kinds of conjunctivitis. Reference has already been made to the fact that certain cases of purulent conjunctivitis, of unfavorable type and accompanied by a thin, watery discharge, are characterized by the formation of a "croupous" membrane, usually upon the palpebral, but occasionally upon the bulbar conjunctiva; and it may be added that a similar disposition occasionally manifests itself in catarrhal conjunctivitis. A typical form of membranous conjunctivitis is that which is induced by the application of the jequirity bean in the treatment of trachoma. In rare instances a chronic form of croupous conjunctivitis is met with, and the membrane forms and re-forms repeatedly for weeks or even months.

In true diphtheria of the conjunctiva the membrane forms upon the bulbar as well as upon the palpebral conjunctiva; but in the milder affection which we are considering the exudate, which does not invade the subconjunctival tissue, as in true diphtheria, and can, as a rule, be easily detached, is commonly confined to the conjunctiva of the lids. The danger of corneal implication is comparatively slight; but there is apt to be marked ciliary irritation and more decided œdema of the lids than is found in catarrhal conjunctivitis. The discharge is scant and watery. After a few days the membrane—which consists of a meshwork of clotted fibrin, pus corpuscles, and epithelial cells—ceases to be formed, and the case assumes the features of a severe catarrhal, or, perhaps, of a purulent, conjunctivitis.

The general condition of the system seems to have much to do in determining this type of conjunctival inflammation. Unhealthy, ill-nourished children—the subjects of inherited syphilis, for example—are especially prone to it. It may also be induced by the injudicious employment of too severe remedies in catarrhal and purulent conjunctivitis, as, for example, unduly strong solutions of nitrate of silver.

The *Treatment* should be constitutional as well as local. Iron and quinine are indicated, and mild applications to the eyes. Boric acid, in ten- to fifteen-grain solution, is useful, as is also a 1 to 8,000 solution of corrosive sublimate. Atropine (gr. i.–℥ i.) may be employed with advantage when there is marked ciliary irritation. After the formation of the membrane has ceased, and the discharge, previously watery, has become purulent or muco-purulent, astringents—sulphate of zinc, alum or protargol, in mild solution—are called for, but should be used with circumspection.

DIPHTHERITIC CONJUNCTIVITIS.—True diphtheria of the conjunctiva, characterized by the presence of the Klebs-Löffler bacillus—to which condition the term diphtheritic conjunctivitis should be restricted—is, as has been said, a disease of extreme rarity. It occurs more frequently in children than in adults, and is one of the most dangerous affections to which the eye is subject. Destruction of the cornea, in consequence of the rapid and extensive infiltration of the ocular conjunctiva interfering with its nourishment, is the result which is most to be dreaded. Speaking of its mode of origin, Nettleship says: "Very rarely the process creeps up to the conjunctiva from the nose in cases of primary diphtheria, or is caused by inoculation of the conjunctiva with membrane; while in a few the ophthalmia forms the first symptom of a general diphtheria." Diphtheritic infection of the eye has also been known to occur after operative procedures. The onset of the disease is sudden, and its development rapid. The lids are not only greatly swollen, but, owing to the solid infiltration into their texture, are tense and brawny.

The membrane may form upon the bulbar as well as the palpebral conjunctiva, is thick and coherent, and extends so deeply into the subconjunctival tissue that it is usually not possible to detach it. The discharge is at first thin, ichorous, and scanty, but at a later stage may become purulent. As in faucial diphtheria, necrotic changes not infrequently occur, and extensive sloughs, involving the subconjunctival, as well as the conjunctival tissue, result. This leads to the formation of scar tissue, the contraction of which may eventually produce incurvation of the lids with its attendant ill consequences.

In the *Treatment* of diphtheria of the conjunctiva, as in that of the faucial variety of the disease, injections of the diphtheria antitoxin should be resorted to as soon as possible after the diagnosis is established. The results of this plan of treatment have been most satisfactory, and, according to Jackson, "its importance overshadows that of all local remedies" ("Diseases of the Eye," p. 252). Quinine, iron, stimulants, and a nutritious diet are also indicated. The local treatment consists in the application of cold or heat (ice-cloths or warm fomentations), as may be more grateful to the patient, unless the cornea be involved, when the former is contraindicated; and for direct application to the conjunctival sac, in addition to atropine or holocaine, antiseptic, rather than caustic or astringent, remedies should be employed. Among these boric acid in saturated solution, and weak solutions of bichloride of mercury, of carbolic acid, and of permanganate of potassium (2 to 100) are the most useful. When the disease is confined to one eye, the same precautions should be taken to prevent inoculation of the other as in purulent conjunctivitis, and those in attendance should be warned of the need of caution lest they should infect their own ocular or faucial mucous membrane. During the declining stage of the disease, after the membrane has been thrown off, the inflammation not infrequently assumes a purulent type. When this occurs, protargol or nitrate of silver, in not too strong solution, may be employed with advantage.

Follicular Conjunctivitis.—The seat of this affection is chiefly in the palpebral conjunctiva. Its characteristic feature is the presence of enlarged follicles—hypertrophied lymphoid tissue—in the superior and inferior retrotarsal folds. In well-marked cases it bears a rather close resemblance to the follicular type of trachomatous conjunctivitis; but there are no so-called "granulations" (hypertrophied papillæ) present, and it does not lead to pannus or deformity of the lids. Nevertheless, it is an obstinate affection, and at times is but little influenced by treatment. It is an interesting fact that the negro race, which is almost immune to trachomatous conjunctivitis, is especially prone to this variety of conjunctival inflammation. It is probably of microbic origin, but this has not been proved. A collyrium of corrosive sublimate (from 1 to 12,000 to 1 to 8,000), dropped into the eyes three times a day, has seemed to accomplish more than any other remedy the writer has employed. Sulphate of zinc and boric acid, as recommended in catarrhal conjunctivitis, alum, and protargol are other remedies which may be found of use.

Trachomatous or Granular Conjunctivitis.—The distinctive characteristics of this form of conjunctivitis, which expends its force chiefly upon that portion of the conjunctiva which lines the lids and constitutes the retrotarsal folds, are its obstinacy, the marked structural changes which it causes in the subconjunctival tissue, as well as in the conjunctiva itself, and the secondary alterations, known as pannus, which it induces in the cornea.

Its pathology is as yet but imperfectly understood. Doubtless it is a contagious disease, the product of a specific micro-organism; but that the small diplococcus, described by Sattler, is the organism which produces it, is yet to be conclusively proven. It is usual to describe two varieties of the disease—a papillary and a follicular. In the former the distinctive feature is hypertrophy of the papillæ of the conjunctiva covering the tarsus; in the latter the presence in the retrotarsal folds of the so-called trachoma granules or follicles. Commonly the affection is of a mixed type, and both of these features are present. The trachoma follicles, which are made conspicuous by everting the lids and causing the retrotarsal folds to protrude, are translucent bodies, not unlike boiled sago grains or frog's spawn in appearance. Recent investigation seems to show that they are, in fact, hypertrophied lymphoid and connective-tissue cells enclosed in a fibrous envelope. The hypertrophy of the papillæ of the tarsal conjunctiva, which is observable chiefly upon the upper lid, and the development of the trachoma follicles are accompanied by pronounced hyperplasia of the submucous connective tissue; and ultimately there supervenes a stage of atrophy which involves all of these structures, and in the worst cases results in the condition known as xerophthalmia, in which the conjunctiva—itself so atrophied that the retrotarsal folds are obliterated, and free movement of the lids and ball curtailed—loses the character of a mucous membrane, and becomes dry and cuticular, and entropion develops in consequence of incurvation of the tarsal cartilage from contraction of the plastic material previously thrown out in the subconjunctival tissues. As Nettleship has pointed out, the palpebral conjunctiva does not undergo ulceration, and, therefore, the trachomatous condition which it assumes is not due to true "granulations," but to the hypertrophy of its papillæ. The secondary changes which occur in the cornea are chiefly, if not entirely, due to the mechanical violence to which it is subjected through constant friction with the roughened inner surface of the lids. The first evidence of corneal implication is a slight roughening of the external epithelial layer. Eventually the cornea becomes more or less opaque; numerous bloodvessels develop upon it; its surface becomes uneven; and sluggish ulcers occasionally make their appearance—these changes being more marked upon the upper half of the cornea, because here the lid friction is greatest.

Although one of the most intractable diseases of the eye with which we have to deal, and in its ultimate consequences as disastrous to sight as any, granular conjunctivitis does not, like purulent conjunctivitis, threaten the eye with immediate destruction. The inflammation does not approach in intensity that which characterizes the latter disease; nevertheless, during the acute stage which supervenes upon inoculation (for, without doubt, the malady always originates in this way) there are frequently considerable swelling of the lids, marked conjunctival injection, and pronounced photophobia, lachrymation, and blepharospasm. The discharge, which is not abundant, is usually mucoid or muco-purulent in character. With the subsidence of these more acute symptoms, the chronic stage of the disease begins, and this, if left to itself, may last for a lifetime, rendering the individual's whole existence miserable, and reducing him to a state of helplessness and dependence.

The *Treatment* of granular conjunctivitis does not usually yield very satisfactory results, and even in the most favorable cases must be long-continued to be effectual. Relapses frequently occur, and even when a complete recovery seems to have been secured, it is wise to give a guarded prognosis as to the future. In dealing with this loathsome malady, prophylactic measures are of the first importance. In this country, at least, as the writer has had occasion to remark before, the disease seems to to be kept alive in institutions, such as orphan asylums and houses of refuge, in which the young are crowded together. Indeed, in the writer's experience, it is an extremely rare occurrence to meet with a case, originating in this country, which cannot be traced, either directly or indirectly, to some such source. If the evil were systematically and energetically attacked in these its strongholds, its complete eradication, it would seem, ought to be only a question of time. Unfortunately, however, it occasionally happens, through the criminal carelessness of those who have the management of these institutions, that the disease is allowed to spread from inmate to inmate, being transmitted usually by means of towels which those with diseased and those with healthy eyes are permitted to use in common. To prevent the possibility of contagion in such institutions, all those with affected eyes should be placed in dormitories apart from the other inmates, and, as far as possible, should be kept entirely away from them. An intermediate class should also be established, in which the doubtful cases (for, as has been stated, the recognition of the different varieties of conjunctivitis is not always an easy matter) should be quarantined.

To combat the disease when it has become established, local remedies are chiefly to be relied upon, although tonics should, of course, be administered when the state of the system seems to call for them. Nitrate of silver, sulphate of copper, alum, tannin, boric acid, yellow oxide of mercury, atropine for the relief of marked ciliary irritation, and infusion of jequirity bean, are the remedies which were formerly chiefly relied upon. More recently the mechanical treatment of trachoma, especially the expression of the trachoma follicles by the roller forceps, has been very generally adopted and has been found to be of undoubted value. Protargol also doubtless has a useful field in this affection, as well as in purulent conjunctivitis.

When, during the early stage of the attack, there is pronounced irritation of the ciliary nerves, manifested by pain, photophobia, and lachrymation, atropine (1 to 100) should be applied to the eyes three or four times a day, and astringents should be used with caution, a collyrium of alum ($\frac{1}{2}$–1 to 100) and boric acid (2–4 to 100), to be dropped into the eyes three times a day, being perhaps the safest to begin with. Protargol (10–20 to 100) may also be used with good effect, even in this stage of the attack, being applied two or three times a day if well borne. When the ciliary irritation has somewhat abated, a daily application of a solution of nitrate of silver (2–4 to 100) should be made with a brush, or a wooden toothpick armed with absorbent cotton, to the inner surface of the everted lids, the excess of silver being neutralized by chloride of sodium if the application causes much discomfort. The anæsthetic action of cocaine may be employed to lessen the pain which the nitrate of silver produces. If the photophobia increases under this treatment, the silver solution should be applied less frequently, or, instead, the everted lids may be touched once in twenty-four or forty-eight hours with a smooth crystal of sulphate of copper. In the mean time the patient should continue to apply, three times a day, the alum and boric-acid solution, or, if this does not seem to be doing good, a weak solution ($\frac{1}{5}$–$\frac{1}{2}$ to 100) of nitrate of silver, or of alum ($\frac{1}{2}$–1 to 100) and sulphate of zinc ($\frac{1}{5}$–$\frac{1}{2}$ to 100). As a substitute for the silver and copper, when these are not well borne, Dr. Noyes recommends a 2–6 to 100 solution of tannin in glycerin.

When the disease has assumed a chronic character, the crystal of copper, and the solutions of protargol (20–40 to 100), of nitrate of silver, and of tannin are still among the most valuable remedies. The "lapis divinus" (sulphate of copper, alum, and nitrate of potash, each 1 part) is also a favorite remedy, and a simple crystal of alum, which may be applied to the palpebral conjunctiva three or four times a day, is another which the writer has sometimes found extremely useful. Again, there are cases which are benefited by the daily application of yellow oxide of mercury ointment (hydrarg. ox. flav., 1 part; vaselin., 30–60 parts), combined with the instillation of atropine. Corrosive sublimate, in strong solution ($\frac{1}{2}$ to 100), to be applied to the everted lids as the silver solutions are applied, is one of the more recently suggested remedies, which has hardly justified the claims made in its behalf.

The indication for the employment of the roller forceps is the presence of the trachoma follicles, the squeezing out or expression of these follicles being the end in view. The eye being under the influence of cocaine and the lids everted, the forceps are made to grasp the everted cartilage, and the follicles are expressed by traction combined with not too firm compression of the blades.

Although in a few instances disastrous consequences have followed the employment of jequirity in the treatment of "granular lids" (cases having been reported in which destruction of the cornea occurred as a result of its use), it has, on the other hand, so often proved of the greatest value, in the very cases, too, in which all other remedies had failed, that the writer feels it still deserves to be looked upon as one of the valuable remedies in the treatment of the later stages of trachoma. Its therapeutical action is dependent upon the acute inflammation which it excites in the conjunctiva and cornea, and which supplants, so to speak, the chronic trachomatous inflammation. A similar effect was formerly sought to be obtained by the more dangerous procedure of inoculating the eye with pus from a case of ophthalmia neonatorum. Its use should be restricted to cases of chronic trachoma in which the cornea is more or less opaque and vascular.

Experience has shown that there is an astonishing difference in the susceptibility of individuals to the action of jequirity, a single application of a 2 or 3 to 100 infusion causing in some persons a higher grade of conjunctival inflammation than a dozen applications of a 5 to 100 infusion in others. For this reason it is wise in all cases to exercise caution in beginning the use of this potent remedy.

A 2 to 100 infusion suffices in most cases to excite the requisite degree of inflammation. A stronger infusion, therefore, need not be employed (and certainly should not be at the commencement of the treatment), unless an insusceptibility to its action is manifested, when it may be necessary to use a 5 to 100, or even a 10 to 100 infusion. After the first application, which should be made with a mop to the everted lids, an interval of at least twenty-four hours should elapse before the treatment is repeated, in order that we may carefully observe the effect produced. Occasionally it will happen, in those peculiarly susceptible to the action of the jequirity, that this first application will suffice to excite the requisite degree of inflammation. More frequently the treatment must be repeated once in twenty-four hours, for three or four days, to attain this end, and not rarely several applications a day, for as long a period, may be required. The inflammation which ensues, as has been mentioned, is of a "croupous" or "membranous" character, and the degree which it is desirable to produce is attended by decided œdema of the lids, considerable increase in the previously existing cloudiness and vascularity of the cornea, and the formation of a "croupous" membrane upon the palpebral conjunctiva. Pain in the eyes and headache are generally present, and not infrequently there is considerable fever, with rest so broken that a liberal use of anodynes is called for. After the jequirity applications are discontinued, the induced ophthalmia usually subsides rapidly, and, unless complications have occurred (such as ulceration of the cornea), no further treatment is demanded. With the subsidence of the inflammation the corneal opacity begins to diminish, and the trachomatous condition of the lids to disappear, and in favorable cases the improvement in vision which results is most gratifying.

In consequence of the croupous character of the induced conjunctivitis, cicatrices are not infrequently left in the palpebral conjunctiva; but the writer is not aware that any case has been reported in which they were of such a nature as to give rise to inconvenience.

Relapses occasionally occur after the jequirity treatment, as they do after every other plan which has been proposed for the cure of this proverbially obstinate affection, and even temporary improvement is not attained in every case. When benefit results, but only to a moderate degree, a reproduction of the jequirity ophthalmia may be indicated, and under such circumstances it will generally be found more difficult to establish it, because of an acquired tolerance to the irritant action of the bean.

It has been suggested that the property of exciting a peculiar type of conjunctivitis possessed by the jequirity is dependent upon a specific bacillus which develops in the infusion, but there appears to be no substantial basis for such a belief. It has seemed to the writer that in preparing the infusion uniformity of strength is more certainly secured by allowing the maceration to continue for twenty-four hours. To preserve the infusion from putrefactive changes, which soon take place, especially in warm weather, boric acid (2 to 100) should be added. By this means the infusion may be kept unchanged for weeks. The beans should be hulled, and then finely ground or crushed. Cold water should be used in making the infusion, and a single filtration through absorbent cotton is better than a slower and more perfect filtering through paper.

VERNAL CONJUNCTIVITIS OR SPRING CATARRH.—This is a very obstinate form of conjunctival inflammation which is chiefly met with in children; it usually attacks both eyes, and is probably mildly contagious. It derives its name from the fact that the affection remains comparatively dormant during the winter and becomes more active and troublesome with the oncoming of warm weather. Though it is probably dependent upon a specific germ, the efforts to discover it have been fruitless.

Two distinct types of the disease are met with. In one, the bulbar conjunctiva is the seat of the characteristic changes; in the other, they occur in the conjunctiva of the tarsus. Well-marked examples of the two types are rarely met with in the same individual; at least, this has been the experience of the writer. In the bulbar variety one finds a slightly elevated, nodular, gelatinous growth, of yellowish-brown color, upon the conjunctiva close to the limbus corneæ. In some instances it exhibits a tendency to encircle the cornea as a rather narrow band; in others it tends to spread upon the conjunctiva, especially in the direction of the inner and outer canthi, and to a less extent upon the cornea. In rare cases the whole cornea is overrun by the growth. The nodular masses, which are stable and show no disposition to ulcerate, are composed of connective tissue and greatly thickened epithelium, the latter showing a tendency to extend into the underlying tissue in the form of solid epithelial plugs (Fuchs).

In the palpebral variety the papillæ of the tarsal conjunctiva, and to a less extent those of the retrotarsal folds, undergo a peculiar hypertrophy, and at the same time become flattened (probably from the pressure to which they are constantly subjected), so that the inner surface of the lid presents a strikingly tessellated appearance. The papillæ are as firm almost as cartilage, and their edges, which overhang in mushroom-like fashion, can be slightly elevated. According to Fuchs, they are composed of a sort of areolar connective tissue, with connective-tissue cells which have undergone a peculiar hyaline degeneration, and are covered by thickened epithelium, which latter gives to the conjunctival surface of the lid the bluish-white, skimmed-milk appearance that is a feature of the disease. These characteristic changes are limited to the upper lids.

The most prominent symptom of vernal catarrh is intense itching. Pain is not complained of, but rather a sensation as though dust or sand were in the eyes. The discharge is slight. In some instances the disease lasts for many years; it is never of brief duration. Not infrequently several cases are met with in different members of the same family. The writer has encountered marked examples of the palpebral variety in a father and son, and also in sisters who were twins. *Treatment* is not of much avail. A collyrium of sulphate of zinc and boric acid, as suggested in catarrhal conjunctivitis, or of bichloride of mercury (1 to 8,000), yellow oxide of mercury ointment, combined in some instances with instillation of atropine, dilute acetic acid (1 part of the dilute acid to 250 of water) as recommended by Van Millingen, and the use of the roller forceps, are some of the remedies which the writer has employed from time to time with a measure of success. The internal administration of iodide of iron he has thought a useful supplement to the local treatment. An ointment of salicylic acid and lanolin (or, still better, vaseline) 2–15 to 100, as recommended by Randolph, is another remedy which at times seems to be serviceable. It should be rubbed into the conjunctiva daily, cocaine having previously been instilled.

PHLYCTENULAR OR SCROFULOUS CONJUNCTIVITIS.—The essential feature of this form of conjunctivitis, which is also known as conjunctivitis lymphatica and as eczema conjunctivæ, is its dependence upon a constitutional cause. The exact nature of this dependence has not been very clearly set forth. In decidedly strumous subjects the resisting power of the tissues is so poor, the cellular instability so marked, that the most trivial irritation, acting locally, may set up a conjunctivitis, as it may excite an inflammation of other mucous membranes, or of the skin or lymphatic glands. Very often, however, phlyctenular conjunctivitis occurs in subjects who cannot properly be considered as scrofulous. This happens especially in young children; and here we frequently find associated with the ocular disease eczematous inflammation of the auricle, of the upper lip, of the tissues about the roots of the finger nails, and not uncommonly suppurative inflammation of the middle ear. A furred tongue, "feverish" breath, loss of appetite, and constipation of the bowels, are the other usual accompaniments of this condition. That in this latter class of cases we have a condition of the nature of septicæmia, the writer has for some time thought probable, and that the infection of the system occurs from the alimentary canal as the result of improper feeding and its consequences, seems equally probable. This view is supported not only by the clinical features of these cases, which are exactly such as we might expect would result from the presence in the blood of a relatively benign septic organism, but also by the nature of the treatment which proves most effective. For not only are the salts of mercury the most valuable of local applications, but of all remedial measures none produces so prompt and decided a change for the better as the administration of a generous, old-fashioned, calomel purge, which rids the alimentary canal not only of much fæcal matter, but also, probably, of myriads of bacteria and their poisonous products.

In the typical form of phlyctenular conjunctivitis the conjunctival injection is not uniform, but is confined to the neighborhood of the phlyctenulæ—yellowish-red elevations varying in size from that of a mustard seed to a split pea and composed chiefly of lymphoid cells,—which make their appearance upon the ocular conjunctiva, and are quickly converted into superficial ulcers through loss of their epithelial covering. In many cases, however, the conjunctival injection is diffuse, and the phlyctenulæ are absent or not distinguishable, so that the eye presents almost precisely the same appearance as in catarrhal conjunctivitis, with which this variety of strumous ophthalmia is very apt to be confounded, if only the condition of the conjunctiva be relied upon as a diagnostic guide. In genuine catarrhal conjunctivitis, however, both eyes are almost invariably affected, and there are no evidences of constitutional derangement; whereas, in the catarrhal type of strumous conjunctivitis, it frequently happens that only one eye is affected, or that the disease makes its appearance in one eye some days before it develops in the other, while it is seldom the case that there are not present other evidences of the constitutional disorder upon which the ocular inflammation depends. In the latter affection, too, blepharitis is often present, and there are usually more decided evidences of ciliary irritation, manifested by pronounced photophobia, blepharospasm, and lachrymation, while the discharge, which is mucoid in character, is considerably less in amount. As the treatment which is called for in catarrhal conjunctivitis (the use of astringent collyria) is almost sure to do harm in strumous ophthalmia, it is of the first importance that these two conditions should be distinguished one from the other. When there is uncertainty upon this point, it is wise to treat the case as one of strumous character. In children particularly this rule should be followed, as they are especially subject to phlyctenular conjunctivitis, and with them the doubtful cases are almost sure to be of this nature. The staphylococcus aureus and staphylococcus albus are often found in the conjunctival sac in strumous ophthalmia, but a differential diagnosis could scarcely be based upon the presence or absence of these organisms.

In phlyctenular conjunctivitis the cornea is very frequently involved in the inflammatory process. In fact, in scrofulous inflammation of the eyes the rule is that both the cornea and the conjunctiva are affected. When this is the case, the photophobia, lachrymation, etc., are usually more severe than when the inflammation is confined to the conjunctiva. Extensive ulceration of the cornea sometimes occurs, but very rarely, except in consequence of neglect or injudicious treatment. The use of astringents (nitrate of silver, sulphate of zinc, sulphate of copper, etc.) always aggravates the inflammation of the cornea, and usually leads to the development of phlyctenulæ upon it, when previously they may have been confined to the conjunctiva. All of the varieties of scrofulous ophthalmia occur much more frequently in children than in adults; indeed, adults very rarely suffer with the disease unless they have had similar attacks in childhood, which have permanently damaged their corneæ, and so rendered their eyes susceptible to recurrent attacks of inflammation.

The *Treatment* of strumous conjunctivitis is very simple, and the results obtained are almost invariably extremely satisfactory, and yet this affection is often improperly treated. In the average medical mind there seems to be an indissoluble connection between the idea of a conjunctival inflammation and that of an astringent collyrium. Given the former, the mind turns intuitively to the latter as the one only therapeutic resource. No exception is made in favor of the variety of conjunctivitis under consideration, and, as may be supposed from what has been said, the consequences of this singular disposition, always unfortunate, are sometimes most disastrous. As has already been pointed out, whenever there is even a doubt as to the strumous character of a conjunctival inflammation the use of astringents should be scrupulously avoided; for not only are the photophobia, blepharospasm, and lachrymation aggravated thereby, but the danger of serious corneal complications is greatly increased.

The treatment which rarely fails to ameliorate the symptoms almost immediately, and, when supplemented by proper attention to the constitutional disorder upon which the local disease depends, in the large majority of cases effects a prompt cure, is the application to the eye three times a day of a solution of sulphate of atropine, and once a day of an ointment of yellow oxide of mercury and vaseline. It is better that the atropine should be dissolved in distilled water, and the strength of the solution should vary from ¼ to 100 to 1 to 100 (gr. i.–iv. to ℥ i.) according to the severity of the symptoms and the obstinacy of the attack, the weaker solution being effective in most cases. The proper strength for the ointment is 2 to 100 (hydrarg. ox. flav., gr. i.; vaselini, ʒ i.). For the effectual application of the atropine solution an "eye dropper" is indispensable, and even with its aid, owing to the spasm of the lids, this is not always easy of accomplishment. The patient should be placed in a recumbent posture, and, if a child, will probably require to be held firmly while the application is being made. The ointment (which should be gotten well into the conjunctival sac) may be conveniently applied on the end of a flat toothpick, or, if the treatment is to be carried out by unskilful hands, more safely by means of a camel's-hair brush. It should be inserted between the upper or lower lid and the eyeball. An ointment of this strength, if properly prepared, does not irritate the eye in the least degree. Some care, however, is necessary in its preparation, for if it be mixed in a mortar or upon a tile which has the slightest trace of iodine, iodide of potassium, or iodoform about it, the oxide of mercury is soon changed to a green iodide, which few eyes can tolerate. For the same reason it frequently happens that the ointment is not well borne when iodide of potassium is being given internally. The ordinary doses of iodide of iron are not apt to give rise to the same inconvenience. Calomel dusted into the eye once a day acts in a similar manner to the yellow oxide ointment, and many use it in preference. In the catarrhal type of strumous conjunctivitis, a 2 to 100 solution of boric acid dropped into the eye three times a day sometimes acts extremely well, and in such cases it is convenient to add the boric acid to the atropine solution. An ointment of yellow oxide of mercury and vaseline cerate, 4 to 100 (gr. ij. to ʒ i.), should be applied to the lids at bedtime, when blepharitis is present.

As for constitutional treatment, which is, of course, of the first importance, when there is a well-marked strumous diathesis, the iodide of iron and cod-liver oil with hypophosphites are especially useful. In the writer's experience, however, the phosphates of iron, quinine, and strychnine (given in the form of a syrup or an elixir) is the remedy which accomplishes the greatest good, more especially in the less distinctly strumous cases previously spoken of as so common among young children. In this form of the disease the writer has also found the preparations of "beef, wine, and iron" very useful, also the "elixir of gentian and tincture of chloride of iron," both of which have the advantage of being palatable, a matter of importance when children are concerned. As a rule, however, and especially in acute cases, and when the ocular inflammation is accompanied by other evidences of constitutional derangement, such as nasal catarrh, otorrhœa, eczema of the face, scalp, auricles, etc., a purgative dose of calomel and rhubarb, or of calomel, rhubarb, and scammony, repeated once or twice at intervals of two or three days if necessary, should precede the exhibition of other constitutional remedies, and not infrequently it will happen that when this has had its effect the case will be so far on the road to recovery that the tonics, which are to follow, will have but little left to do.

The exanthematous fevers are frequently accompanied, or followed, by inflammation of the conjunctiva, and writers commonly make of these cases a distinct variety of conjunctivitis, which they denominate "exanthematous." There seems to be no good reason for doing so, however, as they differ in no essential respect from the systemic conjunctivitis we have just considered, and, like it, present at times a distinctly phlyctenular character, with marked tendency to corneal implication, and at other times a catarrhal type. The treatment, too, which they require is exactly the same.

PINGUECULA.—An elevation, yellowish in color, and varying in size and shape, situated upon the conjunctiva in the interpalpebral space, usually upon the nasal, and less frequently upon the temporal, margin of the cornea, was given the name *pinguecula* (from *pinguis*, fat), because it was formerly supposed to be due to the deposition of fat in the conjunctiva. It is seldom met with in young persons, and is oftenest observed in individuals who have passed middle life. The fact that it occurs upon the most exposed portion of the bulbar conjunctiva seems to indicate that it is, in some measure at least, due to the irritation caused by wind, dust, etc. According to Fuchs, it is a thickening of the conjunctiva, chiefly dependent upon an increase in the number and size of its elastic fibres, and its yellow color is caused, not by the deposition of fat, but by the presence of numerous concretions of a yellowish colloid substance. On account of its unsightliness its removal is sometimes called for, and in other cases, when it is especially prominent, it may cause annoyance and should be gotten rid of. It may be excised with sharp scissors, care being taken to sacrifice as little as possible of the surrounding conjunctiva. The edges of the wound, after being undermined, should be brought together by one or two fine silk sutures.

PTERYGIUM (*πτερυξ*, a wing).—A circumscribed hypertrophy of the conjunctiva and subconjunctival tissue, triangular in shape, more or less vascular, and exhibiting a tendency to encroach upon the cornea. The apex of the growth is always turned toward the centre of the cornea, the base toward the equator of the eye. Its usual location is to the nasal side of the cornea, over the region of attachment of the tendon of the rectus internus; exceptionally it occurs to the outer side of the cornea, and still more rarely above or below it. It usually develops very slowly, and many months, or even years, may elapse without its extending far enough toward the centre of the cornea to impair vision. It is rarely met with in children, and is more prevalent in tropical than in temperate countries. The apex of a pterygium occasionally reaches, but rarely passes beyond, the centre of the cornea. The writer has met with one case, however, in which a pterygium of unusually large size, starting from the nasal side of the eye, grew entirely across the cornea to its external margin. The other eye of the same individual (a woman advanced in years) also exhibited a large pterygium, which had already passed beyond the centre of the cornea. So long as the growth is confined to the conjunctiva and the periphery of the cornea it usually causes little or no inconvenience; but as soon as it encroaches upon the area of the pupil it greatly impairs vision, not only because it obstructs the passage of light into the eye, but because the curvature of the corneal surface about its apex is so altered as to produce a high grade of irregular astigmatism.

In the text-books of forty or fifty years since, four or five varieties of pterygium are described. There seems to be little reason, however, for making even the two varieties which more recent authors mention; although, as some pterygia are thin and scantily supplied with blood-vessels while others are thick and vascular, there is some warrant, perhaps, for calling the former variety *pterygium tenue*, and the latter *pterygium crassum*. The *pterygium pingue* of the older authors is the pinguecula of the present day, which is no longer regarded as a variety of pterygium; while their *pterygium malignum* was, as its name implies, simply a malignant growth involving the cornea, which at the present day one would, of course, not think of confounding with true pterygium. It is possible for several pterygia to develop upon the same eye, advancing upon the cornea from different directions, and cases of this character have been reported, but are of extreme rarity.

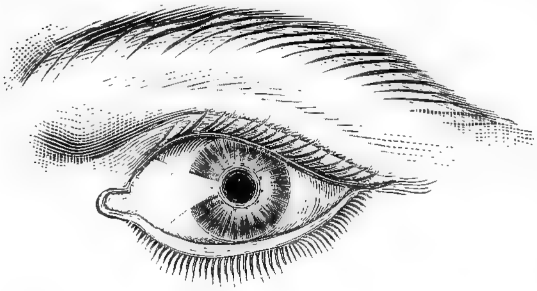

FIG. 1489.—Pterygium.

The question of the etiology of pterygium has from time to time been discussed, and various theories have been suggested to account for its development and growth. Arlt, some years ago, suggested that the starting-point of pterygium is the existence of a superficial ulcer or abrasion at the margin of the cornea, to which the neighboring swollen conjunctiva becomes adherent, and that the dragging and irritation which result from this is the cause of its subsequent growth; and this theory at one time met with very general acceptance. It takes no account of the fact, however, that ulcers and abrasions of the cornea are not especially frequent upon its nasal margin, while pterygium, as we have seen, occurs only very rarely elsewhere; nor of the further fact that many cases of pterygium can be recognized as such before the apex of the growth has even reached the corneal limbus, and, therefore, before the process which is assumed to be the first step in its development has taken place. That pterygium is produced in this manner, in exceptional cases, there is no doubt; but this fact was recognized before Arlt's day, notably by W. Lawrence, who refers to cases of pterygium following purulent ophthalmia, in which the conjunctiva of the upper part of the globe had become adherent to an ulcer upon the lower part of the cornea.* He distinguishes, however, between these cases and true pterygium, and mentions his suspicion that the pterygia said to have been seen on the upper part of the globe were cases of this character, as he had never seen true pterygium in this situation.

It is manifest that any theory which would satisfactorily account for the development of pterygium must also account for the fact that it occurs in so large a proportion of cases to the nasal side of the cornea. This Arlt's theory fails to do; for it is beyond question that if pterygium were, as a rule, produced in the way he describes, we should find it encroaching upon the cornea from every possible direction, and not much more frequently from one direction than from another. The theory proposed by Poncet—that pterygium is a parasitic disease, and that its advance over the cornea is due to the presence of microbia (parasitic "vibriones") which he finds beneath the head of the pterygium, and which are supposed to tunnel their way under the corneal epithelium—fails equally in this respect; and, besides, the precedent ulcer which he regards as the starting-point of the process, and as essential to it, has not been clinically demonstrated, but, rather, assumed to be present.

In endeavoring to reach a satisfactory explanation of the origin of pterygium, it is important that we should bear in mind the fact (which seems usually to have been lost sight of) that in its incipient stage the growth does not, as a rule, involve the cornea at all, but is confined to the sclerotic conjunctiva. As Lawrence very aptly puts it: "It begins with the appearance, in the conjunctiva scleroticæ, of a few vessels rather larger than natural, and running from behind forward nearly parallel to each other. After some time the membrane is found, on accurate inspection, to be a little raised, but the surface is smooth and entire. It gradually assumes the triangular shape, the basis extending toward the circumference of the eye, while the apex passes over the junction of the sclerotica and cornea and advances on the latter." This description of the development of pterygium entirely agrees with the writer's observations, and it suggests at once that the primary cause of pterygium is to be sought for elsewhere than in diseased conditions of the cornea. Fuchs holds that pterygium always originates from pinguecula. The writer cannot accept this view; nevertheless he is convinced that pinguecula does, not infrequently, precede pterygium, and he has occasionally met with transitional types which resembled as closely one as the other of these conditions.

It has long been taught that the development of pterygium is favored by conditions which bring about persistent hyperæmia of the conjunctiva, as, for example, when the eyes are exposed to the heat of a tropical sun, as in long sea voyages, or to the heat from furnaces, as is the case with stokers and founders, or to the irritant action of dust and vapors, as in mills and other manufacturing establishments; and the evidence in favor of this view is much too strong to be put aside. Assuming, then, that hyperæmia of the conjunctiva is an important factor in the production of pterygium, is there any reason why this condition should occur especially where pterygium usually makes its appearance—to the nasal side of the cornea? The writer is not aware that it has been suggested heretofore that the recti muscles of the globe have anything to do with the production of pterygium; but it seems to him highly probable that such is the case. In the first place, it is an extremely rare occurrence to meet with a pterygium which does not lie over the insertion of one of these muscles, usually the rectus internus, less frequently the rectus externus. Again, the vascular system of the conjunctiva in the neighborhood of the corneal border (anterior conjunctival vessels of Van Woerden) is so intimately connected with that of the recti muscles, through branches derived from the anterior ciliary arteries, that the possibility of the blood supply of the former being influenced by that of the latter can scarcely be doubted. There is nothing improbable, therefore, in the assumption that an undue determination of blood to the recti muscles may bring about a hyperæmic condition of the overlying conjunctiva, and that this condition, as we have seen, may in time lead to the development of pterygium. Moreover, it is manifest that the recti interni muscles would be likely to exert a more decided influence in this respect than any of the others; for they are not only the largest of the straight muscles, and the ones which perform by far the greatest amount of work, but their attachment to the sclerotic is considerably nearer the corneal border, and they are, therefore, more intimately connected with the conjunctiva. Thus, in accordance with the theory suggested, the location of pterygium to the nasal side of the cornea is explained.

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* The writer also has met with a case of this character as a result of gonorrhœal conjunctivitis. Only the apex of the pterygium, however, was adherent to the cornea, and a probe could be passed between the corneal surface and the body of the pterygium.

What condition is there, then, likely to produce an undue determination of blood to the lateral muscles? The answer is, an insufficiency of these muscles—an exophoria or an esophoria. In a word, the writer believes that insufficiency of the internal recti muscles is an important factor in the causation of pterygium. His belief is based not only upon the theoretical grounds just set forth, but upon the clinical observation that exophoria is very frequently found in association with pterygium situated upon the nasal side of the cornea. In support of this view of the origin of pterygium (which to the writer seems at least to be more satisfactory than those which have as yet been offered), it may be mentioned, as a matter of observation, that persons who have pterygium not infrequently complain that the pterygium itself, and the conjunctiva in its neighborhood, become bloodshot when the eyes are much used in near work. It remains to be added that pterygium sometimes has its origin in traumatic lesions of the conjunctiva, as, for example, to cite from the writer's experience, a burn from a scale of hot iron or from partially slaked lime splashing into the eye.

In regard to the *Treatment* of pterygium, little is to be expected except from operative interference. In its incipient stage, however, its growth may possibly be arrested by correcting any error of refraction or any muscular defect which may exist; and, even when it has reached a more advanced stage, its development may, perhaps, be favorably influenced in this way. So, too, after any operation which may be resorted to for its cure, the good which glasses may do by lessening the tendency to a recurrence should not be lost sight of. It should be borne in mind that the asthenopic symptoms, of which persons having pterygium often complain, are much more likely to be due to an error of refraction or a muscular defect than to the mere presence of the growth. The propriety of resorting to operative treatment will be determined by several considerations: If the pterygium is confined to the conjunctiva, it may be advisable to operate upon it, provided it is narrow and well defined. If, on the contrary, it is broad and ill defined, it will be wiser not to interfere with it, as the condition and appearance of the eye after the operation will probably not be better than before. If, however, it has encroached upon the cornea, it is better, as a rule, to operate, because, as has been said, it usually advances farther and farther upon this membrane, and, as it does so, it produces such changes in its structure as leave behind a permanent opacity, even when the growth is most carefully removed. Patients will frequently assure the surgeon that the pterygium is not growing, and that for months or years it has made no progress; but their testimony upon this point is not always to be relied upon, and to prevent the possibility of the sight eventually becoming impaired, unnecessary delay in resorting to operation should be avoided.

The operative procedures which have been suggested for the cure of pterygium are numerous. Until a comparatively recent period, excision was the only operation which was in vogue. The results obtained by this method were, however, by no means uniformly successful, the removal of the growth, as it was commonly practised, being not infrequently followed by its recurrence. In consequence of this, various substitutes for this operation were proposed. For example, Des Marres suggested transplantation of the pterygium; Szokalski its destruction by strangulation, while Knapp introduced a modification of the former, and Galezowski of the latter procedure. Pagenstecher recommended that the growth should be dissected from its corneal, and in part from its sclerotic, attachments, and then be allowed to atrophy, the edges of the conjunctival wound being united beneath the partially detached pterygium by means of sutures. Arlt also preferred a method essentially the same as that of Pagenstecher. In Des Marres's operation the pterygium is detached from the cornea and sclerotic quite up to its base, and is then inserted in an incision made in the conjunctiva near the lower edge of the cornea, where it is retained by sutures. Knapp's modification of this method, applicable to cases in which the pterygium is of large size, consists in splitting the pterygium longitudinally, after having removed its corneal portion, and inserting the upper half in an incision made in the conjunctiva above its base, and the lower half in one made below. He also unites the edges of the conjunctival wound by sutures, and, to facilitate this, separates the conjunctiva from the subjacent tissue above and below the wound. In Szokalski's operation the strangulation is accomplished by passing two needles, which have been threaded with the opposite ends of a fine silk ligature, beneath the pterygium, one near its apex, the other near its base, and then, after cutting out the needles, by tying together the ends of the three threads which are thus left in position, so as to cut off its vascular supply near its base, near its apex, and from its sclerotic surface. Galezowski, after dissecting up the pterygium, "takes a thread, armed at each end with a curved needle, and pierces the apex with both needles, so as to include it in a small loop. Then turning the needles inward, he brings them out at the base of the growth, one near the upper and the other near the lower margin. The two ends are then tied in a tight knot, and thus the apex of the pterygium is turned inward toward the base, and the latter is strangulated by the knot." It is claimed for each of these procedures that a recurrence of the growth is less apt to happen than when simple excision is practised.

The operation of excision has, in the writer's experience, yielded such satisfactory results that he has not been tempted to make trial of any of these proposed substitutes. The end which they all aim to accomplish seems to him to be the same—to minimize the loss of conjunctival tissue, and this is, undoubtedly, a most important thing; but, if the excision be performed as it should be, the loss of tissue is insignificant. Although the ill effects of a too free excision of the growth were long ago pointed out, especially by Scarpa, the writer is inclined to think that the poor results which many have obtained from this operation are due to unnecessary loss of conjunctival tissue. Even when but little more than the apex of the growth is removed the gap which is left in the conjunctiva is of considerable size, and when the whole pterygium is cut off, the size of the gap which results, owing to the retraction of the conjunctiva, is surprising. Under such circumstances the healing process is slow and difficult, and not infrequently a conspicuous vascular cicatrix is left, which is as unsightly and as likely to cause trouble as the pterygium itself.

Since the employment of cocaine in ophthalmic surgery the removal of pterygium has been rendered much easier, as the operation is entirely painless. The method of operating which the writer has adopted, and which, as has been said, has yielded satisfactory results, being very rarely followed by a return of the pterygium, is as follows: The eye having been brought under the influence of cocaine, and the patient being seated in a chair, a speculum is introduced and the operator, standing behind the patient, seizes the growth near the apex with suitable forceps, and with an iridectomy knife, which is but slightly bent, cleanly dissects it from the cornea, taking especial care to detach its margins from the corneal limbus. Its more loose attachments to the sclerotic are also separated for a short distance (2 or 3 mm.) from the corneal margin. Then, with a pair of slender scissors, curved on the flat, the whole of the corneal and a very small part of the conjunctival portion of the growth is removed by two converging cuts. If decided traction is made with the forceps upon the detached portion of the growth while the scissors are being used, and if the latter are pressed against the sclerotic, a very much larger piece of the pterygium will be removed than is desirable. Only very slight traction, therefore, should be exerted, and in using the scissors it should be borne in mind that we are more apt to remove too much than too little tissue. If the edges of the conjunctival wound are now slightly undermined, so as to detach them in a measure from the underlying fascia, one or two stitches of fine black silk will suffice to close the wound, and, unless more tissue has been sacrificed than is necessary, will bring its edges together without undue traction. The closure of the wound in this way hastens the healing process, and the removal of the stitches on the second or third day, as may seem more desirable, can be accomplished without pain by the instillation of a drop or two of cocaine. A light bandage should be applied, and may be worn until the stitches are removed. A collyrium of boric acid (gr. x. to aq. destill., ℥ i.), used three or four times a day, soothes the eye, and helps to subdue the inflammation. Should there be much ciliary irritation from inflammation of the corneal tissue, atropine is indicated, while, on the other hand, if there is considerable conjunctival secretion, without ciliary irritation, a very little sulphate of zinc (gr. ¼–½ to ℥ i.) or alum (gr. ss.–i. to ℥ i.) may be added, with benefit, to the boric acid solution. The patient should be warned that the improvement in the appearance of the eye will be slow, else he may suppose the operation has not been successful, and may mistake the vascularity which remains for some time about the former site of the pterygium for a return of the growth. When the pterygium has encroached upon the cornea, he should also be made to understand that after its removal a more or less perceptible opacity will remain. Should this opacity involve the central portion of the cornea, which in exceptional instances is the case, an iridectomy may be necessary in order to obtain a pupil behind a part of the cornea which is clear.

TRAUMATIC LESIONS OF THE CONJUNCTIVA.—The conjunctiva is occasionally torn or cut without injury to the deeper coats of the eye. Considerable extravasation of blood into the loose underlying connective tissue and pronounced œdema are apt to supervene, and the appearance of the eye suggests that the injury is much more serious than is actually the case. The edges of the wound, if they show a disposition to gape, should be brought into apposition with fine, black-silk sutures, and a light bandage should be applied. A collyrium of boric acid is often useful.

Foreign bodies entering the eye frequently lodge upon the cornea, but rarely attach themselves to the conjunctiva of the bulb or to that of the lower lid. Their favorite resting place, however, is the tarsal conjunctiva of the upper lid; and here they give rise to an especial amount of discomfort, because through the movements of the eyeball and the lids they constantly scrape the surface of the sensitive cornea. When the eyelid is everted they are brought into view and can be easily removed—most conveniently by means of a wooden toothpick, about the sharp end of which a very little absorbent cotton has been wound. The writer recalls but one instance in many years' experience in which a foreign body—a small fragment of coal—was found in the superior retrotarsal fold. Probably, when foreign substances enter this region they are carried by the movements of the lid toward the inner canthus and are then easily removed.

Caustic substances, such as lime, lye, and the stronger acids, and molten metal, when they find their way into the conjunctival sac, are likely to do serious damage. An obstinate inflammation of the conjunctiva is almost sure to ensue; but when the caustic action has involved neighboring parts of the bulbar and palpebral conjunctiva, a much more formidable condition is apt to result—an adhesion may occur between the lid and the eyeball, and the condition known as *symblepharon* be established. The treatment of these cases, if they can be seen at once, is the application of an agent which will tend to neutralize the caustic substance that has entered the eye. In the case of an alkaline caustic the conjunctival sac should be washed out with vinegar or acetic acid diluted with water, and if the caustic be an acid a solution of bicarbonate of soda should be similarly employed. The application of castor oil affords relief and does good by protecting the burned surfaces. Still greater relief may be obtained by using a solution of atropine (the alkaloid) in castor oil. Holocaine is another useful remedy.

If a disposition to union between the bulbar and the palpebral conjunctiva manifests itself, every effort should be made to prevent this. The lid should be frequently drawn away from the eyeball and the apposed surfaces should be kept coated with castor oil or vaseline. Success will probably be attained if the retrotarsal fornix has escaped the action of the caustic; but if this has been seriously involved a symblepharon will almost certainly develop in spite of all we may do. And, under such circumstances, any subsequent efforts which we may make to undo the mischief by operative procedure is likely to be equally barren of results. On the other hand, if the symblepharon is band-like and does not extend to the fornix, a good result may be almost always obtained by operation.

ATROPINISM, ETC.—An inflammation of the conjunctiva of follicular type, accompanied usually by considerable itching, is occasionally excited by the long-continued use of collyria containing atropine, eserine, and other drugs of similar character. Indeed, there are individuals in whom a single application to the eye of a solution of atropine will produce a marked conjunctivitis, and not infrequently such individuals are equally susceptible to all of the commonly employed mydriatics, though this is not always the case. For example, the writer has under observation at the present time a case in which neither atropine nor hyoscyamine was tolerated, and another in which atropine excited after a few days' use a marked conjunctivitis, in each of which he is now using sulphate of duboisine without ill effect. The withholding of the drug to which the susceptibility is shown and the use of a collyrium of boric acid will soon restore the eye to its normal condition.

SUBCONJUNCTIVAL HEMORRHAGE.—This condition, which usually manifests itself suddenly, may occur spontaneously or be of traumatic origin. Spells of violent coughing, vomiting, or sneezing may produce it, while in some instances it occurs, perhaps during sleep, without assignable cause. The existence of angiosclerosis predisposes to it as to hemorrhages in other parts. It not infrequently encircles the cornea and spreads over the whole eyeball, giving to it a bright-red appearance, which often leads to the belief that something very serious has happened. It is usually mistaken for "inflammation"; but an inspection of the eye shows at once that the redness is not due to injection of the conjunctival vessels. It may give rise to a slight soreness of the eyeball; but beyond this it causes no inconvenience apart from its unsightliness. During the process of absorption, which may occupy two or three weeks, the bright red color of the extravasated blood changes to a greenish-yellow. Treatment is scarcely called for; but if it is a matter of moment to hasten the restoration of the normal appearance of the eye, a compress bandage and the internal administration of potassium iodide may be of some avail.

ARGYRIA CONJUNCTIVÆ.—From the long-continued application to the eye of nitrate of silver a permanent stain, usually of the lower tarsal and retrotarsal conjunctiva, but occasionally of the bulbar conjunctiva as well, may result. The "white of the eye" assumes an olive color, while the retrotarsal conjunctiva and the inner surface of the lids are stained a bluish-gray or slate color. A similar discoloration of the conjunctiva is said to occur in persons who, owing to the nature of their employment, are constantly exposed to the action of silver dust (Fuchs). Cases of argyria from protargol have been reported, and as this preparation of silver is more penetrating in its action and is used more liberally than the nitrate, it is probable that in the future this condition will be met with more frequently than has been the case hitherto. The stains are indelible. Different agents have been employed to remove them, but without success. *Samuel Theobald.*

CONNECTIVE TISSUE.—Connective tissue, as its name suggests, connects and binds together other structures. If we attempt to remove the skin from the underlying tissues we find it bound to them by delicate, fibrous bands. On further dissection of the body we find the muscles bound together by tissue which, even to the naked eye, is like that under the skin. Sheaths of the same sort are found about the vessels and nerves, beneath the mucous and serous membranes and in many other places. This is connective tissue. Under the microscope it is characterized by an extensive development of the intercellular substance, and it is the intercellular structures and not the cells which are of functional importance. Not only does it comprise the fasciæ, the subcutaneous and subepithelial areolar tissue, and the packing substance about the great vessels and nerves, but, in modified forms, it makes up the groundwork of the spleen, lymph glands and marrow, the tendons, aponeuroses and ligaments, the periosteum and perichondrium, the sclera of the eye, and the membranes of the central nervous system. The supporting tissues—bone and cartilage—are closely related to it both histologically and embryologically. Indeed, no tissue occurs so universally in the body, and it would be useless to try to give a list of places where it is found. All the blood-vessels lie in tracks of it. With them it penetrates every solid organ, and binds together its most delicate parts—the fibres of the muscle or the tubules of the gland. Though inconspicuous, it is as indispensable in the make-up of any organ as are the rivets in the building of a ship.

In order properly to understand the histology of connective tissue and to appreciate the relationship of one of its forms to another we must approach the subject from the embryological standpoint. We will therefore consider first embryonic connective tissue, then the typical adult form, and afterward take up successively the various modifications.

If we look at a section of a young chick embryo we see nothing but cells. We see, moreover, that these cells are of two sorts—differing markedly in shape and still more markedly in their relations to one another. The covering of the body, and the intestinal canal, the rudiments of the central nervous system, and any viscera that may be present will be seen to consist of cells tightly packed together, forming layers or membranes. Such a layer of closely compacted cells is called an epithelium. Lying between these organs, in a position comparable to the straw in a barrel of crockery, is the other kind of cells. These are not united to one another in continuous layers, but are far apart and loosely packed, the interstices appearing empty in the section. This is the "mesenchyma." It gives rise in the further development of the animal to many other things than connective tissue. Still, in the embryo it corresponds so closely, in structure and relations to other parts, to our conception of connective tissue in the adult that it is justifiable to call it "embryonic connective tissue."

If we trace the development of the mesenchyma back we find that it arises from the mesoderm or middle germ layer. A discussion of the development of the mesoderm would be out of place here; but it is enough to say that at one period it forms a fairly compact layer in which subsequently a cavity arises. The epithelium-like lining of this cavity makes up the mesothelium. The rest of the cells of the mesoderm form the mesenchyma.

EMBRYONIC CONNECTIVE TISSUE OF MESENCHYMA consists histologically of (*a*) cells and (*b*) an intercellular matrix (see Fig. 1490).

The cells have large and round or oval nuclei with one or more granules of chromatin. In stained sections the nucleus appears to be distinctly vesicular, and does not color deeply. It often shows karyokinetic figures. In early embryos the nucleus is surrounded by but little protoplasm. Later the amount is greater. The protoplasm is finely granular and no cell wall is recognizable. The shape of the individual cell is stellate, with irregular tapering and branching processes projecting in all directions. The branches of each anastomose freely with those of its neighbors, so that the protoplasm is continuous from cell to cell. Indeed, the anastomosis is often so free and the cell bodies so inconspicuous that the mesenchyma may be described as a network or spongework of protoplasm, with the nuclei at the thick places where the strands meet.

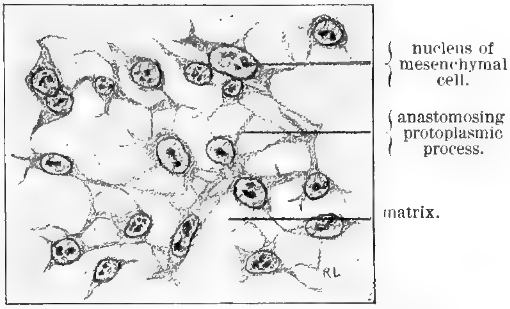

nucleus of mesenchymal cell.
anastomosing protoplasmic process.
matrix.
RL

FIG. 1490.—Embryonic Connective Tissue (Mesenchyma) from Embryo Chick. × 700.

The matrix is an albuminous fluid of slight consistence. It is the intercellular juice of the embryo.

The further development of the mesenchyma into adult structures takes place by virtue of (1) changes mainly in the intercellular substance, (2) changes mainly in the cells, or (3) more complicated changes involving both the matrix and the cells and giving rise to special structures. Thus, for instance, we have fat cells and smooth muscle fibres arising by differentiation of the mesenchymal cells. In such tissues, to be sure, the intercellular substance undergoes modification, but the function of adipose or muscular tissue depends rather upon the cells. The walls of the blood-vessels are examples of the third class of mesenchymal tissues; they show complicated changes both in the cells and in the matrix. But it is with the first class that this article has chiefly to deal—with tissues differentiated from the mesenchyma mainly by changes in the intercellular substance.

This class includes the supporting tissues and the connecting tissues. The supporting tissues are bone and cartilage. Their cells differ from those of the mesenchyma in shape and arrangement, but bone is bone and cartilage is cartilage because the fluid matrix has been replaced by lime salts or chondrin. The same is true of connective tissue. Its distinguishing features and the physical characters to which it owes its function are due to the intercellular structures.

ORDINARY ADULT CONNECTIVE TISSUE consists of the following elements: (*a*) Matrix; (*b*) fibres; (*c*) elastic network; (*d*) cells. The cells and the matrix are present in the embryonic form. All the cells of the adult form of connective tissue are developed from cells of the mesenchyma. The elastic network and the fibres are not found in embryonic connective tissue. These various elements may best be studied by excising small bits of the subcutaneous connective tissue of a rabbit and examining them fresh in normal salt solution (see Fig. 1491).

(*a*) The *matrix* of adult connective tissue is not much different from that of the embryonic form. It is still a soft, homogeneous, albuminous substance.

(*b*) The *fibres* are perhaps the most important, from a physiological point of view, of the constituents of connective tissue. They are long, wavy bundles, running through the matrix amongst the cells. Each fibre is composed of a large number of fine fibrillæ. The latter are filaments of the most extreme delicacy. They do not vary much in diameter, the size of the fibre depending upon the number of fibrillæ, and not upon the calibre of the individual elements. Large fibres may split into smaller ones, but the individual fibrillæ do not branch. The arrangement and relative number of fibres vary in different forms of connective tissue, as will be presently described. They are best stained with Mallory's connective-tissue stain. In large masses they are white in appearance. They are not elastic.

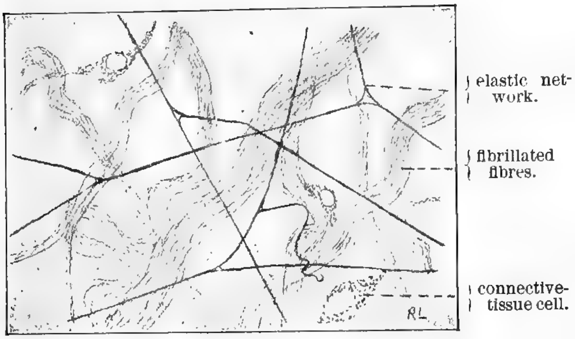


FIG. 1491. Subcutaneous Connective Tissue of Rabbit. Fresh, "teased" specimen. × 350.

On boiling the fibrillæ are converted into gelatin. They swell up and become transparent when treated with acetic acid, and are destroyed by alkalies.

The origin of the fibres is not thoroughly understood. They were formerly thought to arise from the transformation of elongated cells. At present, however, that they arise in the matrix, entirely apart from the cells themselves, by a process more comparable to the formation of fibrin in clotting, seems more probable.

(*c*) The *elastic network* is also intercellular. It differs from the fibres already described in appearance and structure, in chemical and physical properties, and in physiological function. It consists of solid strands of a highly refractile substance. Unlike the white fibres these strands are homogeneous—not composed of fibrillæ. They anastomose freely so as to make a network. In fact, this characteristic is so well marked that it is better not to use the term "fibres" at all in speaking of them, but to speak of the "network," reserving the word "fibres" for the white, non-elastic, fibrillated structures described in a preceding paragraph (Minot). The strands differ greatly in calibre. They may be extremely fine, so that the network is delicate and open-meshed, as in Fig. 1491, or they may be so thick, especially at the anastomosing points, that the network presents the appearance of a solid plate perforated by sieve-like openings. Such a dense mass of elastic material is represented in Fig. 1492. Where one of the delicate strands is broken it usually curls up, as is shown in Fig. 1491. But, throughout all of its variations, the elastic material is always a continuous network.

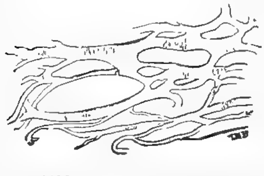


FIG. 1492. Elastic Network from Wall of Artery. × 700 and reduced.

Chemically the network is composed of elastin. This is not converted into gelatin by boiling. It resists the action of acids, so that when tissues containing both fibres and network are treated with acetic acid the fibres swell up and become inconspicuous and the elastic network is brought out very clearly and sharply. It differs from the fibres also in staining reactions and is evidently not at all of the same chemical nature. It is best differentiated by staining with Weigert's resorcin fuchsine. According to Mall the strands of elastin are enclosed in delicate sheaths of a different chemical nature.

In mass the elastic material is yellow, and, as its name implies, possesses elasticity. These properties are the distinguishing features of connective tissue in which it predominates, as contrasted with the white, inelastic tissue in which the fibrillated fibres are in the ascendant.

Concerning the embryological origin of the elastic network there is still some doubt. According to certain observers the network arises from the protoplasm of anastomosing cells, and special relations of the network to the nuclei of the connective-tissue cells have been demonstrated. But the significance of this connection is not clearly shown. This view, like the similar one in regard to the white fibres, is warmly supported by those who, from theoretical considerations, believe that all parts of the organism are composed of cells or their derivatives. A much more plausible view is that the elastic network, like the fibres, is deposited in the matrix and is not formed by direct transformation of cells. Indeed, Ranvier has shown conclusively that elastin is deposited first in the form of little globules arranged in rows which subsequently fuse into plates or anastomosing strands.

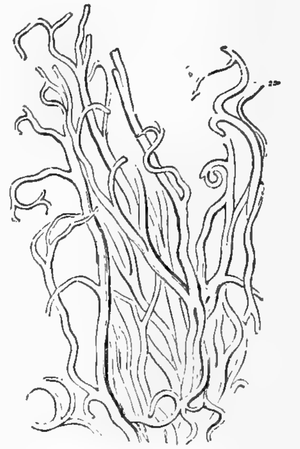


FIG. 1493.—Elastic Network from Ligamenta Subflava. (From Quain's "Anatomy.")

(*d*) The *cells* of adult connective tissue are often much modified from those of the mesenchyma which are their ancestors. The greater part of them are still stellate in outline—and still retain the protoplasmic processes connecting them with each other. But the great development of the intercellular structures has resulted in marked changes in form and appearance. They are flattened and grouped in various ways. They are comparatively few in number. Not only do they tend to be flattened between the fibres, but they form more or less definite sheaths about some of the larger bundles. Such sheaths are at times so complete that the cells are united by their edges as in an epithelium. Perhaps close to these will be found other cells, farther apart and united to one another and to the cells in the sheaths only by their long protoplasmic processes. They may be wavy or elongated. Thus they differ much in appearance.

In addition to these ordinary connective-tissue cells, two special varieties have been described—plasma cells and granular or mast cells. Much confusion exists in the use of these terms, as the original cells described by Waldeyer as plasma cells were afterward described by Ehrlich as mast cells; while Unna applied the term plasma cells to the granular cells of Waldeyer. In this article the terms will be used as applied by Unna and Ehrlich.

Plasma cells are distinguished by the absence of prominent granules in the protoplasm. The latter stains with basic aniline dyes and is often irregularly colored or vacuolated. The cells may be elongated or branched. Although observed in normal tissues they are more characteristic of pathological conditions. Their derivation, significance, and function are unknown.

Granular or mast cells are connective-tissue cells having prominent granules in their protoplasm. These granules stain intensely with certain aniline dyes and have also given the name "eosinophile" to the cells. The latter are more apt to be spherical than the plasma cells. They occur in normal as well as in diseased tissues. As in plasma cells we do not know their significance or function.

Leucocytes are often found wandering about in the intercellular fluid. But they are to be regarded as invaders and not as elements of connective tissue at all.

Besides the protoplasmic granules mentioned as occurring in certain connective-tissue cells the latter may contain two other important visible substances—pigment and fat. Pigment is deposited in the form of dark-brown granules of a substance called melanin. It is found in the irregular, branching cells. The amount varies from a few granules to such a large number that the nucleus is completely hidden. The coloring of many portions of the body, both in man and in animals, is due to cells of this sort. Moreover, the pigment of the epithelium is probably originally of this nature, being formed in connective-tissue cells which wander into the epithelium and deposit their pigment there. Fat is deposited in the cells of connective tissue in much the same way as pigment is laid down in them. Little droplets of fat appear in the protoplasm—mainly in the granular cells. These droplets, at first small, become larger and more numerous till finally they fuse into one large drop. This fills the cell and distends it to many times its original size. The protoplasm remains about the globule of fat as a thin envelope containing at one point the flattened nucleus. Accumulations of such cells bound together by the ordinary elements of connective tissue, and abundantly supplied with blood-vessels, constitute adipose tissue.

To recapitulate: adult connective tissue consists of cells and a fluid matrix, in the latter of which are present two structures, differing from each other histologically, chemically, and physiologically—viz.: white, non-elastic, fibrillated fibres, and a homogeneous, yellow, elastic network. The cells are of four kinds: common flattened or lamellar cells, plasma cells and granule cells, all of which are true connective-tissue elements, and wandering leucocytes which are not to be regarded as connective-tissue cells at all. Connective-tissue cells may contain fat or pigment.

Adult connective tissue may be classified according to the predominance of one or the other of its intercellular elements, as fibrous, elastic, and fibro-elastic.

In *fibrous connective tissue*, which is perhaps the most typical and widespread form, the fibres predominate over the elastic network. Examples are seen in the aponeuroses, the tendons and ligaments, the periosteum and the dura. All these structures are white when seen in mass and will not stretch.

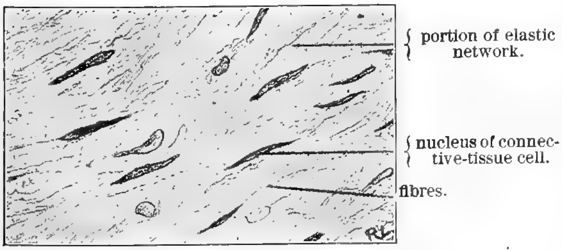

portion of elastic network.
nucleus of connective-tissue cell.
fibres.
RL

Fig. 1494.—Section of Connective Tissue from Wall of Vagina. Only the nuclei of the cells—not the protoplasm—can be seen. × 700.

In *elastic connective tissue* the network predominates over the white fibres. The resulting tissue is yellow in macroscopic amounts and is capable of stretching much and then returning to its original condition. The classical example is the *ligamentum nuchæ* of large quadrupeds, like the horse. In these animals the ligament extends from the vertebral spines to the occiput and supports the head. When the head is depressed the ligament is stretched, and it acts as a sort of spring when the head is elevated again. In man, according to Shäfer (Quain's "Anatomy," vol. i.), it occurs as follows: (1) In the *ligamenta subflava*, between the vertebral arches, where its elasticity permits the spine to be flexed. (2) In the stylo-hyoid and crico-thyroid ligaments and in the vocal cords and trachea. (3) In the coats of the blood-vessels.

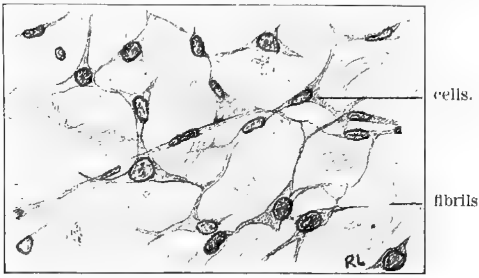


Fig. 1495.—Mucous Connective Tissue from the Umbilical Cord. × 332.

In *fibro-elastic connective tissue* both fibres and elastic network are present in considerable quantities. Stretching is hence allowed, but the elasticity is limited. It will of course approach fibrous tissue on the one hand and elastic tissue on the other. The classification here given is merely one of degree, and no sharp boundary lines can be drawn. The best example of fibro-elastic connective tissue is perhaps the adventitia of the larger arteries. Here we can readily recognize both the fibres and the elastic material. Other good examples are seen in the submucous layers of the œsophagus and of the vagina (see Fig. 1494).

In stained microscopical sections of ordinary connective tissue we recognize all the elements described. The fibres usually make up the greater part of the section. Their direction and compactness will be evident at a glance and will of course depend on the source of the specimen examined. The elastic elements are white (yellow only in macroscopical amounts), glistening, and highly refractile. They usually form thick, wavy bands lying amongst the fibres. Though not difficult to recognize in stained sections, it is impossible in a drawing like Fig. 1494 to even approximate their actual appearance. They are best studied by the beginner in the walls of the arteries.

The cells, in dense forms of connective tissue, are flattened between the wavy bundles of fibrillæ. This makes it difficult to recognize the protoplasm, so that about all we see of them in sections is the nuclei. As the latter also conform to the pressure of the surrounding fibres they are elongated and wavy and often have characteristically pointed tips. This pointed shape, together with their deeper staining, is in sharp contrast to the nuclei of smooth muscle fibres with which students are disposed to confuse them. They stain very deeply and homogeneously, so that in ordinary specimens little or no intranuclear structure can be made out.

In the foregoing description, I have dealt with the typical form of connective tissue, such, for example, as occurs beneath the skin or mucous membranes. There remains to be described the various special modifications, all of which are best understood by remembering their embryological evolution. We have also to define certain more or less appropriate terms in common use.

Mucous connective tissue or "Wharton's jelly" (Fig. 1495) is only slightly modified from the mesenchyma. The cells remain almost unchanged. Their small, protoplasmic bodies surrounding the rather large, vesicular nuclei send off tapering processes. The latter branch and anastomose freely with those of neighboring cells. The large intercellular spaces are filled with mucin, and there are also a few poorly developed fibres. The mucin gives the whole the peculiar jelly-like, translucent look in gross amounts, which is familiarly seen in the umbilical cord. The umbilical cord represents its only normal occurrence in man. It is more abundant in lower forms of life. In the human adult it is not normally present at all. Pathologically it is seen in myxomata, the commonest example of which is the ordinary nasal polyp.

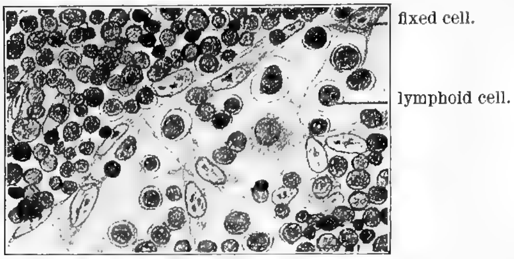


FIG. 1496.—Reticular Connective Tissue from Lymph Gland of Dog. The upper left-hand portion of the figure consists of adenoid or lymphoid tissue. × 600.

Reticular connective tissue is a highly specialized form of connective tissue found in the spleen, lymph glands, tonsils, the solitary and agminated follicles of the intestine, the submucosa of the digestive tract, and in other places. Its structure has always been obscure. Ordinary microscopical sections show little more than a mass of nuclei. These are easily seen, however, to be of two sorts (see Fig. 1496). Some are small, deeply stained, and round. Others are often oval, larger, vesicular in character with a well-marked nuclear membrane and with nuclear contents staining but faintly save for one or more granules of chromatin—in other words, nuclei like those of the mesenchyma. Careful study of favorable sections will show some of the protoplasmic bodies of the cells to which these nuclei belong. The outlines of the cells to which belong the small dark nuclei are simply circles—in other words the cells are like the young mononuclear leucocytes and are hence called "lymphoid" cells. The other nuclei are sometimes surrounded by irregular masses of protoplasm with obscure branches. They are the fixed connective-tissue cells of the part. The lymphoid cells are not fixed, but may be regarded as simply floating in the matrix. The differences between the two types of cells are well shown in the accompanying illustration (Fig. 1496).

If we treat a section in appropriate reagents and shake it vigorously before mounting, most of the lymphoid cells may be removed and the other parts show more clearly. Such a section shows a network of rather large anastomosing strands containing the nuclei of the fixed cells. Its appearance resembles very closely that of the omentum of certain animals, such as the dog. Here instead of being two layers of flattened epithelial cells with a little connective tissue between, as in man, the omentum consists of an open-meshed network of delicate fibres, the latter being surrounded by tube-like sheaths of cells, so that the whole is like a sieve full of holes. Ordinary specimens show neither fibres nor cell outlines, but only the nuclei lying upon the strands of the network. Now shaken sections of reticular tissue look like this, except that the fibres are not all in one plane, but run in many directions.

This appearance has given rise to a controversy in which the last word has not yet been spoken. Does the reticulum consist of a network of cells alone, or of fibres alone, or of fibres with cells in close relation to them? It seems to the writer that this question is answered by specimens in which all of the cells have been removed by digestion, or in which only the fibres are stained. In such sections we still see a network of fibrillated fibres interlacing and crossing one another in all directions so as to make a framework. These fibres, in organs like lymph glands, are continued directly into the more densely packed fibres of the capsule. In the fresh state the fibres are surrounded by the flattened connective-tissue cells which make sheaths, more or less definite, about them, in much the same way as do the endothelial cells in the dog's omentum. That this is the case is also proven by staining in such a way as to show the outlines of the individual cells. This flattening out of mesenchymal cells to form membranes is seen in many other regions,—notably in the endothelia of the blood-vessels. The intercellular, anastomosing processes are doubtless preserved, and if we assume that these fixed cells are also connected by their protoplasmic processes with the connective-tissue cells in the capsule the relations become clear. Each of the fibres of reticular connective tissue, then, consists of a central core of fibrillæ surrounded by a more or less definite tube of flattened mesenchymal (endothelial) cells. According to Mall the fibres in reticular connective tissue differ both from the white fibres and from the yellow elastic network, and consist of a third substance called reticulum.

The terms *adenoid tissue* and *lymphoid tissue* refer to a form of reticular tissue whose spaces are filled full of floating lymphoid cells, so that the fixed cells are vastly outnumbered. Such tissue is found in the tonsils, the secondary nodules of the lymph glands, the Malpighian corpuscles of the spleen, the solitary follicles, and Peyer's patches of the intestine. This tissue is represented in a portion of Fig. 1496.

Areolar or *interstitial tissue* is a loose form of connective tissue where the fibres and strands of the elastic network run in all directions, not being disposed in layers. Such is the tissue shown in the teased specimen represented in Fig. 1491. It is perhaps the most typical form of connective tissue. It occurs underneath the skin and mucous membranes, about the vessels and nerves, and in the various places where its function is to connect loosely parts between which a considerable degree of motility is required.

Fibrous membranes, like the periosteum and perichondrium, the fasciæ and the dura are made up of connective tissue of the adult type. The fibres are especially well developed and make up the greater bulk of the tissue. They are densely packed together so that there is little fluid matrix. A small amount of elastic network is present even in places where elasticity is hardly a feature of the gross membrane, as in the periosteum.

Ligaments and tendons (Figs. 1497 and 1498) are also made up of dense connective tissue, the most marked histological peculiarity being that the fibres all run in the same direction and are gathered into parallel bundles. The cells occur between these bundles, their form and arrangement being determined by the positions in which they lie. Thus they form characteristic chains, as is well shown in Fig. 1498. It will be noticed in such longitudinal sections that the nuclei are generally near the ends of

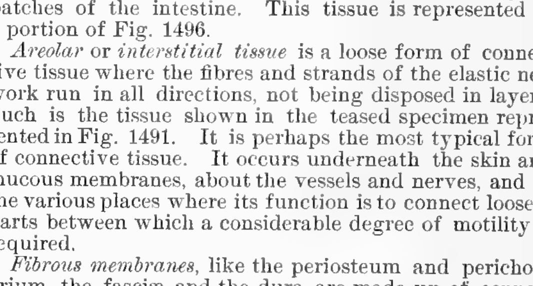


FIG. 1497.—Cross Section of Tendo Achillis. × 332.

the cells. Often the cells appear to be in groups of two, for the reason that the nuclei of a pair of cells are in the adjacent ends of their respective cell bodies. The nuclei may be flat or they may be round or oval. In such longitudinal sections we see little trace of the stellate form that the cells once had when they formed part of the embryonic mesenchyma. In cross sections (Fig. 1497), however, we see a strikingly different picture. We now have stellate cells whose long processes anastomose freely—those of one cell with those of another. In fact, each tendon corpuscle sends out lateral lamellar processes, lying in planes parallel to the general direction of the tendon, and these lamellæ break up into the anastomosing branches. Hence the striking difference in appearance between cross and longitudinal sections.

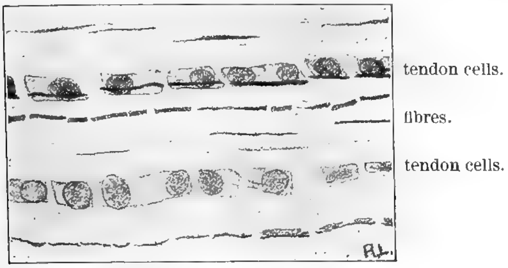


FIG. 1498.—Longitudinal View of Tendon of Rat's Tail. × 450.

There are many other special modifications of connective tissue, such as the submucosa of the uterus and the cornea and sclera of the eye, but these are best treated in connection with the organ to which they belong. There are also tissues belonging to the third group in the classification of mesenchymal tissues—structures developed from the mesenchyma by changes both in the cells and in the intercellular matrix. These are not commonly classed as connective tissue at all, but they are closely allied to it. Take, for example, the walls of the arteries. Nothing enters into their composition but mesenchymal cells and the various intercellular structures of connective tissue. The flattened endothelial cells of the intima are modified mesenchymal cells, as are also the smooth muscle-fibres of the media. The elastic plate of the intima and the fibres and elastic tissue of the adventitia are the same intercellular structures found in connective tissue.

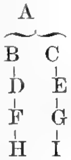
Such structures as these are not classed ordinarily as connective tissue at all. In concluding this article, however, the writer wishes to emphasize the importance of the embryological aspect in understanding not only the histology of the various forms of connective tissue, but also their essential unity. *Ralph C. Larrabee.*

For bibliography, consult: Quain's Anatomy, vol. i., 1891. p. 243. C. S. Minot: Human Embryology, 1892. J. Disse: Das retikuläre Bindegewebe, in Ergebn. d. Anat. u. Entwickelungsgesch., Anat. Hefte, vii., 1897, p. 9.

CONSANGUINITY.—This term denotes blood relationship, and is to be distinguished from affinity, which signifies relationship by marriage. The husband bears the same relation to certain individuals by affinity that the wife bears by consanguinity. But two persons, each related to a third person by affinity, have thereby no affinity for each other.

The principal importance, from a medical point of view, of the subject of consanguinity is in the effect produced upon offspring by the fact of such a relation existing between the parents. In part from a belief in the injurious effects upon offspring of marriages between near kin, in part from the influence of authority, and in part from a natural repugnance to such unions, legal prohibitions have been placed in many countries upon marriages between persons who are within certain specified degrees of consanguinity. In some instances these restrictions have been extended from the field of consanguinity to that of affinity. In England, for example, for the past two hundred years it has been illegal for a man to marry his deceased wife's sister, a relation obviously not within the bounds of consanguinity at all.

Consanguinity may be either lineal or collateral. The former is reckoned between persons in the direct line of descent, either downward from progenitor to descendant, or upward from descendant to progenitor. Collateral consanguinity exists between two persons descended, not the one from the other, but both from some common ancestor. The degree of consanguinity is measured in the first instance by the number of generations separating the two individuals. Thus grandfather and grandchild are in the second degree of lineal or direct consanguinity. In defining the degree of collateral or indirect consanguinity two different methods have been used, which have given rise to some confusion. By the civil law the degree is measured by counting the number of generations upward from one individual to the common ancestor, and thence downward to the other. By the canon law the number of degrees are counted only in one line (that which is the longer of the two) from the common ancestor.



Thus, supposing F and G to be great-grandchildren of A, and hence second cousins, as by the accompanying diagram, according to the civil law they would be in the sixth degree of consanguinity, while by the canon law they would be in the third. The imperfectness of the latter mode of reckoning is shown by the fact that G would also be in the same degree of consanguinity, viz., the third, to A, B, and D; but in the fourth degree to H, the count then being made in the other, or longer line. Evidently, a prohibition of marriages within the third degree, made by the civil law, would become much more onerous if interpreted in accordance with the canon law. This was actually done by Pope Gregory I. (A.D. 590–604).

Much diversity has prevailed among different nations in their views concerning the marriage of kin. The traditions of the ancient mythologies, in their account, for instance, of the relations between Jupiter and Juno, and between Osiris and Isis, show that unions in the closest collateral degrees of consanguinity were not considered abhorrent. On the other hand, the story of Œdipus and Jocasta indicates that marriages in the direct line of descent were looked upon as impious. The ancient Egyptians intermarried very closely, and in the history which we possess of the dynasty of the Ptolemies, a large proportion of the marriages are seen to be between brother and sister. In other nations of the East, notably among the Persians, marriage in the nearest degrees, even of direct consanguinity, prevailed. There is evidence that prior at least to the time of Moses this custom prevailed among the children of Israel. This very nation was descended from consanguineous unions. Abraham married his half-sister, Sarah, Isaac married Rebecca, his first cousin once removed, and Jacob his two first cousins, Rachel and Leah. Yet no one has ever questioned the vigor of the Israelites, who, in the first fourteen generations from their origin, became six hundred thousand fighting men. Indeed, a literal interpretation of the record in the Book of Genesis would indicate that the sons of Adam must have married their sisters, and that the whole human race is the product of a consanguineous marriage in the closest degree. The restrictions placed upon the marriage of relatives by the Mosaic law are worthy of special attention, because they have remained, to a great degree, in the usage of Christian nations in modern times. The following marriages were prohibited on the score of kinship by the Levitical law (Leviticus xviii.): That with a parent, or with a stepmother; with a sister, or half-sister; with a granddaughter; with an aunt, or an uncle's wife; with a son's wife; with a brother's wife; with a step-daughter, or a step-granddaughter; with a wife's sister, *during the lifetime* of the former. The Greeks, while forbidding marriages in the direct line of descent, permitted them between half-brothers and half-sisters; the Athenians allowing the marriages of brothers and sisters by the same father, but not of those by the same mother; and the Lacedæmonians, on the other hand, allowing uterine brothers and sisters to marry, but not those having a common father—an obviously arbitrary distinction.

The Romans held still stricter views. Not only the direct line of consanguinity, as well as brothers and sisters, either in whole or in half, were excluded from intermarriage, but any union within the degree of first cousin was practically illegal, the occasional marriage of uncles with nieces in the times of the Tarquins and of the emperors being held to be a stretch of despotic authority. The Institutes of Justinian, the basis of the modern civil law, forbade marriages in the direct line, and in the collateral line within the fourth degree. First cousins and all remoter kin might marry. The Roman Catholic Church extended the restrictions, discouraging, and then forbidding unions between first cousins. Various councils in the early centuries altered the rules, usually in the direction of greater exclusiveness. The present canon law, that of the fourth Lateran (twelfth general) Council, A.D. 1215, in force in most Roman Catholic countries, permits marriages only outside the fourth degree, *i.e.*, third cousins are forbidden to marry. The Church, however, reserves and exercises the power of allowing dispensation from this prohibition. The civil law permits marriage in the fourth (civil) degree, that is, allows first cousins to marry. The Greek Church allows third cousins to marry, but prohibits all nearer relations. In England the ecclesiastical prohibitions on this subject were at first even more stringent than those of the present canon law, but under Magna Charta they were modified so far as to admit marriage outside the fourth canonical degree.

The restrictions of the canon law were set aside in England by the Marriage Act of 1540, in the reign of Henry VIII., and the prohibitions of the civil law, practically the same as those of Leviticus, were substituted. Marriages may be made in the fourth and all remoter degrees, computed according to the civil law. Hence first cousins may marry, as may also nephew and great-aunt, or niece and great-uncle. Indeed, by the letter of the law, as has been pointed out, while a man may not marry his grandmother, he may marry her sister. This law affects England, Scotland, Ireland, and all the British colonies. It is worthy of remark in this connection that the prohibition of marriage with a deceased wife's sister, which is not Levitical, and which, in spite of an annual effort to remove it, is still maintained in the home country, has been removed in most of the British provinces.

In the various States of this country the degrees of consanguinity in which marriage is prohibited are practically those of the Levitical code. A few of the States, however, forbid by law the marriage of first cousins, and, on the other hand, in one or two, a man is allowed to wed his aunt or his niece.

The difficulties in the way of obtaining accurate knowledge as to the production of evil effects in offspring by consanguineous marriages are very great. In the first place, in the absence of State registration covering this point, people are apt to resent inquiries as impertinent. Especially is reluctance manifested if the children have any physical or mental defect. Secondly, upon persons who collect and record such cases among their own acquaintances, instances of evil results are liable to produce more effect than negative cases, which, presenting nothing of importance, drop out of notice, and the fact of consanguinity on the part of the parents is quite forgotten. Thirdly, in some of the unfavorable cases collected, too little attention is paid to the moral elements of the case. For instance, in the family of the Ptolemies, where the intermarriages were very close, whatever may be claimed as to the physical degeneracy of the stock (and there seems to be very little ground for Mr. Francis Galton's remark as to its sterility) may be in considerable degree ascribed to the enervating physical and moral effects of unlimited despotic power. Other tabulated lists prepared to show the evil effects on offspring of marriages between relatives include unions nearer than the fourth degree. But close incestuous unions presuppose moral degradation, and this cannot fail to have its effect on the physique both of parents and of children. Some of the figures collected upon this subject have been obtainable only from records of public institutions, and are based, for the most part, only on the lowest classes of society. But where, as in the individuals included in Dr. Howe's statistics, "most of the parents were intemperate," it would evidently be unfair to conclude that the large percentage of idiots among the children was due entirely to the consanguinity of the parents, and not in large part to their intemperance. Again, accounts have been published of certain European communities, geographically isolated, where numerous consanguineous marriages have occurred. Granting that there is no moral obliquity in these individuals, there is certainly very little ambition or enterprise in men who are content to stagnate in the same spot where their ancestors have lived for generations, with no curiosity to learn what lies outside the borders of their hamlets. Fourthly, confusion exists between the effects of consanguinity and those of hereditary morbific transmission. Where two relatives wed, both of whom possess a similar disease or tendency to disease, the offspring are very likely to inherit the disease, the latent tendency even becoming a patent actuality. But this is the fault of the morbific strain multiplied into itself, and thus raised, as it were, to its second power, and not of the mere fact of consanguinity in the parents. For the same result would follow the union of two persons not related if they possessed some defect in common; and, on the other hand, in the breeding of animals, while the parents are blood relations, yet such care is taken to select perfect specimens that no chance is allowed for the propagation of a fault. This point, which is of great importance, will be again alluded to later on. Fifthly, and finally, it should be remembered that positive cases in which the marriage of relatives has been found to give numerous and perfectly healthy children are more significant and important than negative instances, where perfect children did not follow such unions. Because in the latter case the imperfection may have been due to other elements than the consanguinity, whereas, if the fact of consanguinity in the parents constitutes *per se* an obstacle to the propagation of healthy children, defective offspring should follow in all or nearly all cases wherever that bar to perfect offspring, to wit, consanguinity, existed in the parents.

With the above provisos as to the interpretation of statistics bearing upon this point, we will now examine some of these reported facts.

Dr. Bemiss ("Report on Influence of Marriages of Consanguinity upon Offspring," Transactions of the American Medical Association, 1858, vol. xi., p. 334) collected a large number of cases of marriage between relatives, which tell strongly against the safety of such unions. Eight hundred and thirty-three such marriages are reported, including cases of incest between parent and child, and brother and sister. The average number of births was 4.6. An extract from his table is given on the next page. This table presents the case against consanguineous marriages with its full strength. Yet, as the author himself says: "It is natural for contributors to overlook many of the more fortunate results of family intermarriage, and furnish those followed by defective offspring or sterility." One other vulnerable point in these figures presents itself. Marriages between third cousins are much more productive of evil results in the offspring than marriages between second or even first cousins! In other words, the eighth degree of consanguinity, which is so remote that persons occupying it must often be ignorant that any kinship at all exists, really constitutes a greater danger to marriage than relationship in the fourth degree.

Dr. Mitchell's statistics ("Memorandum before the Anthropological Society of London," vol. ii., 1866, p. 403), also classical upon this point, are based upon 45

Classes of Relationship.	Number of observations.	Average number of births.	Defective, per cent.	Deaf-mutes, per cent.	Blind, per cent.	Idiots, per cent.	Insane, per cent.	Epileptic, per cent.	Scrofulous, per cent.	Deformed, per cent.	Died young, per cent.
A. Incest with parent, or between brother and sister	10	3.10	93.5	....	....	61.2	....	3.2	16.1	35.4	....
B. With niece or aunt	12	4.42	75.4	1.9	5.6	5.6	1.9	1.9	20.7	26.4	43.3
C. With blood relations the issue of blood relations	56	4.18	53.8	4.2	5 1	12.8	1.2	1.7	18.8	3.8	26.9
D. With double first cousins	27	5.70	27.2	1.2	1.2	2.5	3.8	1 2	6.3	1.2	35.0
E. With first cousins	580	4.80	24.9	4.2	2.2	8.3	....	1.6	6.2	1.9	22.5
F. With second cousins	112	4.58	13.0	1.7	....	3.3	....	1.1	2.9	1.7	16.5
G. With third cousins	12	4.92	27.0	5.0	....	1.7	1.7	3.4	16.9	....	13.5
H. With first cousins, irregularly reported	24	5.00	17.5	2.5	....	2.5	1.6	....	12.5	....	10.0
Total	833	4.6	28.7	3.6	2.1	7.0	2.04	1.5	7.6	2.4	22.4
Compare marriages with persons in no way related	125	6.7	2.1	0.35	0.1	0.71	0.1	0.35	0.1	....	6.0

cases of consanguineous marriage. Eight couples were barren, and the remainder produced 146 children; an average of about 4 for each fertile marriage, or of 3 for all marriages, barren and fertile. Eight children were idiots, 5 imbecile, 11 insane, 2 epileptic, 4 paralytic, 2 deaf-mutes, 3 blind, 2 defective in vision, 3 deformed, 6 lame, 1 rachitic, 22 consumptive, scrofulous, or manifestly of weak constitution.

Dr. S. G. Howe's tables, computed from Massachusetts statistics (*Journal of Psychological Medicine and Mental Pathology*, July, 1858), have been already referred to. These marriages produced 95 children, an average of 5.5 each. Forty-four were idiots, 12 scrofulous, 1 deaf, and 1 a dwarf.

Huth, in the appendix of his work ("The Marriage of Near Kin"), from which some of the above observations have been taken, has gathered a series of 299 cases from many sources, a considerable portion being from writers who disapprove of consanguineous marriages. The catalogue of diseases referred to this cause is long, numbering nearly forty. The total children born were at least 1,155 (3.8 per marriage), and in 83 of the families there were no unhealthy children.

It will thus be seen that those who condemn consanguineous marriages *ipso facto* have presented a very extensive catalogue of charges. Those most generally dwelt upon have had relation to what may be called the social functions of the individual. As Guipon, representing this opinion, puts it (*Comptes Rendus*, vol. lvii., p. 513), "consanguinity exerts a depressing effect on the vital forces, notably upon reproduction, so that if sterility is not observed in consanguineous marriages themselves, it at least shows itself in their children. It affects the functions of relation and the organs of sense, hearing, speech, and sight. The genital sense is exalted, but its natural end and aim is thwarted."

On the other hand, numerous and reputable observers have reported many cases where consanguineous marriages were unattended by any degenerative conditions in the offspring. For example, we have an instance reported by M. Dally (*Anthrop. Review*, May, 1884, p. 95), where two families continually intermarried for five generations, no marriage being in a more distant degree than first cousins, except two of second cousins. The total number of branches direct and collateral was 120 to 140. There was not a single case of deaf-mutism or idiocy, but there were 2 cases of consumption, 1 "caused by a cold," and 1 case of senile insanity in a woman of sixty-eight. It should be remarked that there was no predisposition to disease in the family.

Perhaps the most striking instance on record of consanguineous marriages without ill effect upon offspring is furnished by M. Bourgeois (*Comptes Rendus*, vol. lvi., p. 178). The family in question is his own. A genealogical table is given covering seven generations. In one branch of the family, of five successive generations four married their cousins, and the offspring of the fourth successive consanguineous marriage consisted of six children all perfectly healthy save one, who is defective mentally—a defect, however, ascribable to an accidental traumatic injury. The founder of the race himself married a kinswoman, and among the descendants seven others have married cousins. Indeed, of the sixty-eight unions that have occurred, all feeling more or less the influence of consanguinity, but one has been infertile, and that infertility was due to disease of the mother, who was an alien; on the husband's side, moreover, it was necessary to ascend three generations to reach the first union of cousins. Among the two hundred individuals of this remarkably inbred family, all are very healthy, except the children of one of the latest marriages, in some of whom a tuberculous taint has appeared.

M. Voisin collected some observations bearing strongly on the favorable side of consanguineous marriages. In the commune of Batz, in Brittany, was a population of 3,300 souls, quite isolated from the rest of the department. In 1864, M. Voisin found in that community 5 marriages between cousins-german, 31 between cousins of the next degree below, and 10 between cousins of the degree after that. The first class produced 23 children free from all constitutional disease, 2 only having died of casual disorders. The 31 marriages of second cousins produced 120 children, all free of constitutional taint, 24 dying of acute disorders. The 10 marriages of third cousins gave 29 healthy children, of whom 3 died of accidental diseases. Sterility occurred in only two families, the parents being related to each other in the third degree (canonical). Mental disorders, idiocy, deaf-mutism, and hemeralopia were all unknown. The general health of the population was good.

The same author states, as the result of a careful examination of 1,077 of his patients at the Bicêtre and Salpêtrière hospitals, that in no one instance of his idiotic, epileptic, or insane patients could healthy consanguinity be legitimately regarded as the cause of the affection.

M. Seguin gives the result (*Comptes Rendus*, vol. lvii., 1863, p. 253) of ten consanguineous marriages occurring in his own family. One marriage was barren, but the average children in each of the ten marriages was over six. There was not a single case of deaf-mutism, hydrocephalus, impediment of speech, or supernumerary digits among all the children.

One great difficulty has been, in considering the returns of defective children born from consanguineous marriages, that we have no means of knowing what the proportion of consanguineous marriages themselves is. Until this latter element is learned we cannot tell whether the defective children of relatives are or are not numerous out of proportion to the children of the non-related. It is very desirable, therefore, that by some authority, like that of the census, the number of consanguineous marriages be ascertained. This, unfortunately, has never been done. A formal request to this effect was made by a scientific body of the director of the Eleventh United States Census, but was denied.

Mr. George H. Darwin, however, has collected some valuable and novel observations upon this point (*Journal of the Statistical Society of London*, July, 1875; also, *Fortnightly Review*, July, 1875).

This writer, by means of ingenious computations which space is insufficient to allow of giving in detail, concludes that in London, comprising all classes, the first-cousin marriages are about 1½ per cent. of all marriages; in the urban districts, 2 per cent.; in the rural districts, 2¼ per cent.; in the middle and upper middle class, or in the landed gentry, 3½ per cent.; and in the aristocracy, probably 4½ per cent.

Mr. Darwin then collected returns from a number of lunatic and idiotic asylums regarding the proportion of the inmates who were the offspring of consanguineous marriages, and found that where the figures obtained were most reliable, the proportion exceeded but slightly, if at all, the ratio of first-cousin marriages in the country at large, being from three to four per cent. Among deaf-mutes, also, the offspring of first-cousin marriages was almost exactly the same as the proportion of such marriages for the town and country.

Regarding the fertility of first-cousin marriages and of the descendants of such marriages, against which Professor Mantegazza, M. Boudin, and others have pronounced, Mr. Darwin finds, from figures obtained from "Burke's Landed Gentry" and the "Peerage," that the fertility, as shown by the number of sons surviving infancy, is somewhat greater in marriages of first cousins, and where one of the parents was the child of a first-cousin marriage, than when the parents were not consanguineous, the average number of sons in each of these three classes being respectively 1.92 to 2.07, 1.93, and 1.91. As to the youthful death rate, the evidence, from the small number of families (37) for which these data existed (all from the peerage), gave a slightly increased death rate in early years for the children of consanguineous parents.

While admitting a certain amount of truth in the popular sentiment in regard to the evil effects upon offspring of marriages of kin, Mr. Darwin holds that the evil has been much exaggerated.

The writer of the present article collected a series of cases of consanguineous marriages, whose results were embodied in a paper read before the Massachusetts Medical Society, June, 1885, and published in its "Proceedings" for that year. In 108 such unions 103 were fertile, producing 413 children. Excluding from the category of the "healthy" all who had any physical defect, including even polydactylism and strabismus, all who were below the average in mental or bodily vigor, all who developed phthisis or any other constitutional taint, even though it did not appear till late in life, and all who died in infancy, except when the death was known to be from some acute malady, 312 of the children, being 75½ per cent. of the whole number, were classed as healthy. The principal diseases and defects comprised 12 cases of deaf-mutism (all occurring in a small isolated community on the island of Martha's Vineyard), 7 of insanity, 13 of idiocy, and 15 of consumption. The fertility of all of the unions which were known to have lasted twenty-five years or over, 57 in number, was on an average 5 children to each couple.

There were 17 consecutive consanguineous marriages, *i.e.*, those in which one or both the parties marrying in kinship were themselves descended from a similar union. Of these marriages only 9 had lasted the whole child-bearing period, and these produced 50 children. In all, from the 17 marriages, 15 being fertile, 68 children were born, of whom 48 were "healthy."

There were also 128 marriages not consanguineous, but to which one or both of the parties were descended from persons related. Some of the marriages had lasted but a short time; but 110, or 86 per cent., had already proved fertile, with at least 372 children, and probably many more. Only 47 of the unions were known to have lasted twenty-five years or over, and these produced 240 children.

An analogy of considerable significance to the question of consanguineous unions in the human subject is to be drawn from the so-called in-and-in breeding of animals. Bakewell, the brothers Collings, and Bates, in England, were the first to advocate and practise incestuous breeding among cattle. The Leicester breed of sheep and a breed of long-horned cattle were created by Bakewell on this plan, and with a good measure of success. The "Duchess" short-horned cattle, produced by Bates in the same manner, were also famous for a time, but have now become nearly extinct. Cattle breeders at the present time are divided in opinion as to the advantages of thorough in-and-in breeding, some claiming that this method in time will impair the fertility of the stock, and pointing for proof of this to the numerical deterioration of some of the breeds first formed on this plan. Their opponents say, on the other hand, that as long as Bakewell himself lived to give the benefit of his judgment to the selection of the individuals to be bred from, the stock retained its excellence. Moreover, there are numerous examples to be adduced in which incestuous breeding has succeeded in not only developing, but perpetuating a breed for long periods. M. Beaudouin tells (*Comptes Rendus*, August 5th, 1862) of having inbred merino sheep very closely for twenty-two years without in any degree diminishing their fertility. The "Jersey" cattle have for one hundred and fifty years been bred on a small island only six miles by eleven (no larger than a western ranch), with no intermixture of foreign blood; yet, when first known to the outside world they were already an established breed, noted not only for their excellence as butter-makers, but for their beauty, docility, and intelligence. The early importations of these cattle to this country were, of necessity, very closely inbred. Indeed, some of the most striking instances of in-and-in breeding on record are among Jersey cattle. Take, for instance, the St. Helier strain. This bull was put successively to his daughter and granddaughter, and by the latter begot a son (Oxoli), which was also a great-grandson, and a daughter (Chromatella), which was also his great-granddaughter. Each of these animals had 87½ per cent. of the blood of their great-grandsire (seventy-five per cent. more than has a child by a non-consanguineous union). Chromatella was bred to the son of her brother Oxoli, and dropped two daughters, both healthy and good breeders. Oxoli also bred to three daughters of St. Helier (having fifty per cent. of the latter's blood), one of them being his own (Oxoli's) granddam. He also bred to several cows having seventy-five per cent. of the blood of St. Helier, of which he himself had 87½ per cent. In fact, the history of this strain shows a large number of unions of the very closest possible nature, a great majority of the descendants having more than fifty per cent. of the blood of their progenitor. Yet for excellence not only of the butter record, but of general health, and for fertility, the strain is most remarkable. Again, the bull Favorite, himself highly inbred, was put successively to his daughter, daughter's daughter, and daughter's daughter's daughter, he being the sire in each case. The result of this last union was a cow having 93¾ per cent. of the blood of Favorite, and the mother of some of the most remarkable animals known.

Among racing horses "Rysdyk's Hambletonian" may be mentioned as an example of a closely inbred horse. Yet it is stated on good authority that during the year 1883, among 190 new performers that entered the list of 2.30 trotters, 41 per cent. were by Rysdyk's Hambletonian, his sons and grandsons; while 20 per cent. of the residue were more or less closely related to Hambletonian.

It is important to bear in mind that what is called "in-and-in breeding" among cattle breeders, means a closeness of mating which is not only out of the question in the human subject on ethical considerations, but is far beyond the bounds of physical possibility. In mankind, a marriage between first cousins would give the offspring but twenty-five per cent. of the blood of the common ancestor of the parents. The child of parents who are uncle and niece will have thirty-seven per cent. of the blood of the common ancestor; and even the product of the union of brother and sister will have but fifty per cent. of the blood of one of its grandparents. In other words, unions equivalent in closeness to the nearest consanguineous marriages made among men are not considered by cattle-breeders worthy the name "in-and-in" at all. Mr. Campbell Brown, speaking (as a disbeliever in incestuous breeding) of a horse that had been claimed as closely inbred, says "that he had only twenty-five per cent. of the blood of a certain other stallion," and adds "that that is a degree of inbreeding to which there can hardly be rational objection." Yet this is just the per cent. which the child of first cousins has in the blood of their common ancestor.

In comparisons between the results of in-breeding in animals and in man, we are to remember of course that in the former case there is a studied selection of the qualities in the individuals to be mated, while in the union of human beings affection is usually the only guide.

In estimating, however, the effect of consanguinity pure and simple as an element in the determination of offspring, it is proper to take it where it is free from all possible complication by inherited morbid influences. If cattle breeders, in their endeavors to perpetuate a fine breed by the principles of natural selection, can win success out of in-breeding, it follows that there is nothing in the fact of consanguinity itself in parents which of necessity deteriorates the offspring. When, therefore, it is objected that human consanguineous marriages should not be compared to in-and-in breeding among animals, for the reason that in the former the principles of natural selection are not observed as they are in the latter, it may be answered that what is the same in the two classes of animal is unions of kindred, and that it is those similar conditions only which it is sought to compare. It is not denied that "like produces like," whether of bad or of good, and if a union of two imperfect individuals of allied blood produces diseased or defective offspring, it is in obedience to a law of nature too universal to be affected in any way by the accident of consanguinity.

The objection has also been made that the product of in-and-in breeding is not a perfect animal, but is, as Dr. Mitchell has expressed it, "a saleable defect," a "perfect pathological specimen," less useful to himself if he were to be left to himself and deprived of artificial care and keeping than the natural animal would be under like circumstances. Here again the influence of consanguinity has been confounded with that of natural selection. In accordance with the latter principle, any quality may be selected as the aim of breeding—as speed or strength in the horse; milk, draught, or flesh in cattle; wool or fat in sheep, etc. According to the point of view of the observer will the product of such breeding be intrinsically beautiful and valuable, or the reverse. A breed of pigs may be produced so fat that they cannot stand, and certainly "less useful to themselves" than in a natural state. Yet we have it on the best authority that no horse bears fatigue so well, or recovers from its effects so soon, as the thoroughbred. "Indeed," says an eminent hunting authority, "there is scarcely a limit to the work of full-bred hunters of good form, constitution, and temper." The argument that the thoroughbred animal is less "useful to himself," because he has become dependent on artificial conditions of food and shelter, would prove equally well that civilized man is inferior to the aborigines.

Deaf-mutism is a defect which has been said to bear a special relation to marriages of near kin. This general impression is doubtless due to the undeniable frequency of deafness among the children of unions where one and especially where both of the parties are deaf. This liability is greatly enhanced if the deafness of the parents is congenital, or if either of them has deaf relatives. On this ground Professor Bell has urgently advised that deaf-mutes, if they marry, should select hearing persons and those too, only, who have no deaf relatives. He says that a deaf person (not born deaf) who has no deaf relatives will not increase the liability to deaf offspring by marrying a blood relation; but a congenital deaf-mute under the same conditions he thinks will. While a deaf person, so born or not, who has deaf relations will especially increase this liability in the offspring if he marries a relative on the same side of his family in which other cases of deafness have occurred.

Boudin asserted that deaf-mutism was specially selected by Providence as the punishment for the violation of "nature's law" involved in consanguineous marriages, in order that man, as the "talking animal," may bear the brunt of the penalty! But Dr. Child has shown that deaf-mutism is simply a congenital deafness to which mutism has succeeded because the individual cannot hear himself speak, and that the same defect, congenital deafness, may and does exist in the lower animals. Indeed, the whole drift of modern science is against such attempted distinctions. Man is physiologically an animal, and in the manner of his propagation is subject to the same laws as any other animal. If, then, as seems to be the case, analogies drawn from the lower animals show that even "in-and-in breeding," in the hands of practical men working for pecuniary returns, gives good results in the form, usefulness, and fertility of their stock, it is a fair inference that at least the occasional admixture of a comparatively small amount of kindred blood, involved for instance in a marriage of cousins, is innocuous in the human species.

How, then, shall we reconcile the above conclusions with figures such as those published by Bemiss, Howe, Mitchell, and Boudin? Have no unfortunate results been found from consanguineous unions? Undoubtedly; but such results have followed for the most part, and probably exclusively, where consanguineous marriages have intensified morbid characteristics of both parents. Such unions may transmit and intensify admirable attributes as well as undesirable ones. Children have a tendency to revert to a common ancestor. If the common ancestor of both parents is not a remote one (by reason of their consanguinity), the type to which the child reverts is not the common type of the race, but is that of this comparatively recent ancestor, say, a grandfather. Should that ancestor possess exceptionally desirable qualities, the child stands a chance to be above the average of its fellows. But if this common progenitor has a depraved or diseased quality of mind or body, it is more likely to find expression in the child inheriting from him in two lines, than in that inheriting from him only in one. Because any newly acquired taint in an individual is much less likely to lose itself in his descendants if diluted in an extraneous strain than if intensified by being multiplied into itself, and so going on in a sort of geometrical increase.

It must be admitted that many families do possess physical and mental traits whose perpetuation would be undesirable. And it is this fact which lends whatever danger there is to consanguineous marriages. It is perfectly true that what has been called "social consanguinity" in marriage is open to much the same objections as true consanguinity. If marriages are constantly contracted within the same locality and social environment, the resultant offspring may become as eccentric mentally and feeble physically. Certain royal families have suffered perhaps as much from the lack of this social dilution as from anything else short of the actual in-breeding of disease.

To conclude, a danger exists to the offspring of related parents if these parents are sharers in any family disease or tendency thereto, and not otherwise.

Charles F. Withington.

CONSCIOUSNESS, DISORDERS OF THE.—In any discussion, having for its object the setting forth of some aspects of the subject of "Disorders of Consciousness," it is desirable that certain features of normal consciousness should be presented, and yet from the very complexity of this latter subject such a preliminary for the present purposes might seem fruitless.

In the present exposition it is assumed that it is not known what consciousness is: one is cognizant only of what one feels at any particular moment. Reasoning along such lines many modern psychologists assume the "stream-like character of consciousness," with its continuous flow; the moment's consciousness being in focus as the stream goes by. This moment's consciousness is made up dimly of the apperceptions of things about to come into consciousness and faintly fringed about with perceptions which have come and gone or are out on the edge of the conscious field. Thus in every moment's consciousness there are parts which are vivid and sharply outlined, and parts, probably by far the greatest number, which are faintly foreshadowed and dimly outlined, and still others which make an impress somewhere on the cerebral mechanism, which never under ordinary circumstances are known, and are thus truly called sub-conscious. Thus, restricting the consideration of a moment's consciousness, there exists an immense gamut of conscious perceptions which may be traced through the various grades of definiteness to the vast mass of sub conscious contacts. This gamut even with the most primitive intelligence is of immense scope, and its complexity, for man, in time and in space, and as registered on the organs of sight, hearing, touch, taste, smell, and the various illy defined sense organs, with their sensory elements, is of the complexity of human life and human experience.

Digressing for a moment, it is a corollary that anything which interferes with any incoming tract, by cutting out a certain path of incoming sensations, interferes with the character of the moment's consciousness and with the interpretation of it by the subjective ego and society at large. Such a corollary has its obvious relationship to many of the insanities, especially bearing on the development of hallucinatory and delusional states, since many of these have been shown to be based on organically defective sense organs conveying defective sense perceptions.

Lloyd Morgan's categories of the various conscious states is here partly followed. Certain molecular disturbances bring about psychical states. Those disturbances which are dominant become focal in consciousness, or the mind is fully conscious of such. Those that are sub-dominant bring about marginal or sub-conscious psychical states, and finally those impulses or irritations which are infra-dominant act, in the psychical sphere, below the threshold of consciousness and bring about infra-conscious or extra-marginal psychical activities. All of these have their determining influence on conduct; and conduct is the chief if not the only objective sign by which we can judge of conscious states in others than ourselves.

CEREBRAL LOCALIZATION.—The general biological principle of the concentration of energy as a feature of advanced evolutionary development finds its expression for the psychical sphere in the more or less distinct localization of definite functions to certain portions of the brain.

For the purely vegetative activities such localization is fairly definite, and we know that the areas governing the various members are accurately located. The important sense organs also show a like integration, and the localization of the centres for sight, hearing, smell, and motor speech now admits of little question.

It is, by more or less common consent, based on general grounds, as well as on the data afforded by physiological experiment and pathological observation, as well as by the study of the comparative psychology of the lower animals (Romanes, Darwin, Morgan, Mills, and Thorndike), that the higher mental processes (*i.e.*, those that are more complex and those which have developed late in the evolution of the race) are located in the frontal lobes of the brain; but it is certain that as far as the ego, taken in its totality, is concerned, no such localization can exist. The whole brain is the psychical organ, and the sense of the ego depends on such a multitude of sensory impressions that its location is coexistent with the nervous system in its totality. It is to be borne in mind that the complex nexus of associational fibres should be considered constant factors in the idea of a consciousness. The great modifications that occur in consciousness—due to the cutting out of action of certain of such associated fibres—is a constant feature in certain hemiplegic states, and probably some similar pathological entities lie at the foundation of some of the modifications of consciousness in some of the insanities, notably general paresis.

Within recent years the labors of the histopathologists have brought into prominence the importance of minute structural changes of the connections of the various nerve processes; collaterals, axis cylinders, and dendrites, forming plexuses of communication between various systems of nerve-cell groups. Such changes are closely correlated and are the probable direct causative agents of many of the symptoms of mental disease, such as loss of attention, diminished initiative, amnesia, blunting of the higher ethical ideas, insomnia, and many of those psychical activities which modify conduct so largely, and hence are representative of the empirical ego. As put by Mills, from Andriezen: "The earliest changes in many if not most of the insanities are in the cortical fields of conjunction, the regions in which anatomical units or groups of them are brought together. These fields of conjunction become less and less permeable to all forms of excitation, and one of the first results is 'delay in reaction time.' The association system, which gives way first in these cases, is probably represented most in the polymorphic layer of the cortex; it is the last and the least organized, although subserving the highest functions, especially volition, and in chronic processes of disintegration it is the first to go."

From such a purely preliminary sketch it can be seen that it is futile to attempt to speak of a localization of consciousness as if such a faculty were a thing *per se* rather than an attribute of psychical nerve activities.

Connected, however, with this question there are to be considered certain localizations of some of the more clearly defined psychical activities.

Evidence derived from the lower animals points to the fact that following the ablation of the prefrontal lobes there is more or less mental degradation. Close attention is lost, and observation which looks for the safety of the animal is often notably affected. Attention, judgment, memory, and notably inhibition are factors of the ego which are notably modified by disease or injury to the frontal lobes, and with such are associated hesitation, fear, uncertainty, and motor restlessness due to impaired inhibition.

Much discussion has been indulged in with reference to the functions of the basal ganglia and the relations of such to the phenomena of automatism, double consciousness, and the like. While much is known from the investigations of Ferrier, Ziehen, March, Danilewsky, Hale, White, Bourneville, and others relative to lesions in the caudate and striate nuclei, little of definite value for generalization has been thus far adduced. Cortical connections are definite though slight.

Much the same uncertainty exists for the functions of the thalamus; its connections, however, with the cortex are more direct, and it is widely believed that it serves as a special centre intermediate between special sensory centres and the cerebral cortex. The symptomatology of pure thalamic involvement is still uncertain.

WHAT ARE DISORDERS OF CONSCIOUSNESS?—From the unconsciousness of death and that of accident, and the profound intoxications, to sleep; through the simple stages of consciousness in many of the sleep phenomena, somnambulism, the hypnotic state and its allies; through normal waking consciousness; through the active exalted states of dramatic abandon, ecstasy, the minor intoxications, to the distinctly diseased emotional states of hysteria and epilepsy and the insanities, finally to the living death of dementia, there is the gamut of the human psychical activities divided into a few cardinal categories which admit of general classification.

Just what shall constitute a normal state and what an abnormal state must be left largely to the study of majorities. Conduct is the great criterion of consciousness, and for most practical purposes it may be assumed that disordered consciousness is correlative with disordered conduct.

In discussing the subject of disordered consciousness it has been the custom to describe three types: exalted, diminished, and perverted states. While this classification is extremely convenient for many purposes, it fails to give an idea of the clinical significance of any particular phase. It is only too frequently the case that the same clinical entity, hysteria or epilepsy, for example, will demonstrate all these separate states, which at times merge within each other or follow one another with bewildering rapidity.

The more important question seems to be: Given a definite mental state, which, judged from conduct, departs so far from what a broad experience teaches to be a fairly normal state, to what factor or factors is such an abnormal state due, into what category does it fit, and how can it best be regulated or controlled to insure the best results to the individual and to society?

The subject of categories of the clinical groupings of such disordered conscious states will be here only touched upon. Such a problem in classification is manifestly extremely difficult because of the extreme richness of the emotional content of consciousness, and the few rather broad categories here proposed are to be regarded purely in the light of general convenience rather than as attempts to cover the entire ground.

The disorders of consciousness for the present purposes are broadly divided into a few general groups. These are: (1) Disorders of sleep and the allied phenomena; (2) disorders of the neuroses, hysteria and epilepsy, including the phenomena of automatism, double consciousness, amnesia, etc.; (3) the intoxications; and (4) the insanities. Such a classification is manifestly incomplete and imperfect. Thus many of the phenomena of groups (1) and (2) are interchangeable. It is moreover popular at the present time to attribute most of the psychical ills to various toxæmias, either autogenous or heterogenous, and it is certain that no hard-and-fast line can be drawn clinically between certain maniacal states due to intoxication and those of primary etiology. In the present unsettled conditions of neural pathology, to say nothing of psychological classification, the question of categories may be an academic one after all.

1. *Disorders of Sleep and Allied Phenomena: Dreams, Somnambulism, Trance, Lethargy, Catalepsy, Hypnotism, etc.*—Under this category there are included a large number of closely allied phenomena, the most striking feature of which is what it is at present popular to call a dissociation of consciousness. In most of these phenomena the ordinary waking conscious state, with its refinements of judgment, inhibition, etc., is in temporary abeyance, naturally or artificially induced, while the more primitive states of consciousness, the ordinary motor functions, are active.

Somnambulism.—The simplest type of such is found in some somnambulistic states. In these the individual may perform, while still asleep, many of the simpler acts of the waking state, and indeed even many extremely complex acts are carried to completion. The patient awakes without any knowledge whatever of the acts performed, and often such actions have been harmful to self and society.

The clinical phenomena are not constant. The eyes are frequently closed or semiclosed, or even wide open and staring. The pupils are apt to be sluggish in their reactions, but may be normal in diameter, dilated or contracted. The data collected by Gould and Pyle* may be referred to by those who would learn more of the complicated motor acts that many notable cases have been known to perform. Suicide and homicide have been committed by persons in the somnambulistic state.

The most important etiological factor seems to be heredity. This is usually associated with a highly neurotic or emotional temperament.

Nightmare.—These represent some of the simplest forms of the pathological condition. In many instances, where such are extremely distressing, they have been known to precede grave cerebral disturbance. Cerebral congestion, hemorrhage, paresis are often associated with markedly disagreeable nightmares. As they influence conduct but little, they are to be regarded as disordered states only in certain severe cases.

Lethargy, Catalepsy, Trance.—These are terms used to describe abnormal subconscious states which are as yet imperfectly classified, partly on account of the fugitive character of the alterations and partly because of the complications of the picture with other symptoms of the hysterical and epileptic conditions. The phenomenon of hypnotic sleep is best put in this category.

In catalepsy the prevailing phenomenon consists of the wax-like rigidity which the limbs can be made to assume, at times unconsciously; again, especially in the hypnotic condition, by the suggestion of the operator. In trance conditions there may be manifest a great variation of phases, most of which are accompaniments of the hysterical state.

Hypnotic States.—Hypnotic subconscious states are too involved and complex to be more than touched upon. Medical and psychological literature is full of interesting instances. Many false phenomena are undoubtedly collected and made to pass as true hypnotic phenomena; but, notwithstanding such, there seems to exist a certain type of consciousness which may be placed in such a condition as to be peculiarly capable of manifesting the conditions of dissociation, so that two different states of mental activity may be made to appear, on suggestion, following proper methods of induction. Such mental states may be totally different and the patient may exhibit many grades of amnesia with reference to the other state. Space does not permit a fuller discussion of this peculiarly induced condition, which is often reproduced in certain pathological conditions, notably in hysteria and epilepsy (see *Hypnotism*).

2. *The Disordered Conscious States of Hysteria and Epilepsy.*—These two neuroses, so closely allied at some points, are often associated with such marked modifications of consciousness, which present so many points in common, that they are discussed as part of the hysterical or epileptic phenomena. These have been termed by various names, but more particularly are classed as perversions of consciousness, amnesic states, automatism, double consciousness, etc. There are observers who claim that all such states, when noted in nature and not artificially produced by the influences which bring about the hypnotic state, are due to the hysterical or epileptic influence. This is warmly disputed, but the study is too much in its infancy to admit of positive dicta, and we prefer here to class these conditions as epi-phenomena of these neuroses.

The celebrated case of Dr. Jekyll and Mr. Hyde illustrates the central type of the phenomenon. The personality may suffer but a very short and transitory change, or it may undergo serious modification, as it undoubtedly does in many epileptics, and for a considerable length of time. Craig Colony for epileptics is filled with patients who show double personalities, covering a space of weeks or even months, during which their ordinary personality has been considerably modified. There are cases recorded in literature which seem to be bona fide where such an alteration has persisted for years.

Automatism.—Some of the minor grades of automatism are well illustrated in epilepsy. The patient may or may not suffer from a pronounced epileptic attack, but following one he may be noted to go about, sometimes in a dazed condition; then again, he may even resume playing a game of baseball profoundly oblivious of what he is doing, and yet be able to catch and toss the ball as though in his normal state. Altered emotional tone is especially common in the hysterical or epileptic automatic. Crying, weeping, intense anger, culminating in the homicidal impulse, may be the prevailing note of the altered personal state.

Amnesic Conditions.—Cases too numerous to mention have been reported in literature of the gradual or sudden loss of memory of a former state of existence. The person lives in new surroundings, under new impulses, and there occurs just as sudden a reversion to the memory of the former condition and a total loss of memory respecting the second state of consciousness. Some of the most interesting of these are collected in Dana's article in the first edition of this Handbook (Vol. II., pp. 277 *et seq.*)

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* "Anomalies and Curiosities of Medicine."

Many of these cases show psychical states which are in the borderland between the sane and the insane and as such are worthy of the most careful analysis, and these are capable of the most interesting experimentation. Their relationship to the hysterical and epileptic symptom-complex should be kept in mind. It is impossible to enter into all of the details of such amnesic and automatic states. The countless varieties of the hundreds of cases that have been reported now make up an imposing mass of literature. It seems clear, however, that they occur for the most part in the highly strung neurotic individual, the artistic and emotional déséquilibrée.

3. *The Intoxications.*—It is only necessary to call to mind the altered mental states brought about, in man, by the toxæmias of the microbian diseases. The maniacal states of scarlet fever, diphtheria, typhoid, pneumonia, and other diseases are too well known to require further details. The muttering delirium of renal insufficiencies is also of this type.

The altered mentality induced by alcohol is also too well known to need further description; and the same is true, although to a less extent, of the mental states of the habitué to morphine or cocaine.

Cannabis indica, as is well known, brings about a condition of altered subjective personality which is interesting, but the reader is referred to that drug for its consideration. Like the following category, this subject is taken up only that the mosaic may show some pattern.

4. *The Insanities.*—The final stage in the gamut of disordered conscious states falls into the loose category of the insanities. Here the prevailing note is markedly anti-social conduct, and the individual and society are at loggerheads. It is not the purpose of the present article to discuss the insanities, and they are here included more for the purpose of rounding out the general conception of what is in the present article regarded as the "Disorders of Consciousness." Even in the insanities there can be traced the final stages of many of the milder forms of disordered conscious states. The analogies of a *melancholia attonita*, for example, to hysterical paralyses are suggestive, even if apparently far fetched, and certainly the vagaries of a major attack of hysteria, so far as the emotional content is concerned, pass by insensible stages into many maniacal states. The present writer would not push the analogy too far, however, but would employ it merely as suggestive of the continuity of the mental activities which both in their normal and abnormal manifestations present such a richness of variation as to defy all categorical classifications.

Smith Ely Jelliffe.

CONSTIPATION.—This term is applied to an abnormal sluggishness in the movement of the intestinal contents through their canal. In extreme cases, when the bowel becomes entirely closed up, one speaks of the condition as obstipation. When there is a movement daily, but the amount is small, so that an accumulation takes place within the intestine, it is called costiveness. It is obvious that there is no sharp line separating constipation from health. But in general it may be said that most persons to be in health require to have a stool daily. Exceptions do occur; some people habitually have an operation only once in two days, and show no signs of suffering for the lack of a daily evacuation; others habitually have more than one discharge a day. The dejection should be moderately soft in consistence, and cylindrical, not spherical, in form.

Among the symptoms, other than infrequency and incompleteness of defecation, may be mentioned headache, furred tongue, foul breath, muddy complexion and conjunctivæ, a sense of weight in the abdomen. The constipated condition may even be masked by a diarrhœa affecting only the lower bowel, while an actual impaction exists above. At times, moreover, in the cæcum and colon hard masses may accumulate in sacculi in the periphery, while a moderate amount of liquid fæces flows along the centre of the gut. Many of the symptoms of constipation are those of dyspepsia, the two conditions often co-existing, and mutually aggravating one another.

The causes of diminished bowel action are numerous. First may be mentioned mechanical or structural causes, including adhesions, bands resulting from inflammatory deposits, new growths within and without the intestine, constrictions, invaginations, twists, for whose discussion the reader is referred to their appropriate heads. The non-structural causes only will be considered in this article. Dilatation of the intestine with atony is, perhaps, the commonest cause of constipation. The fault lies especially in the large intestine, which is intended especially as a receptacle for the fæces. Normally, they rest, in the intervals of defecation, in great part upon the sigmoid flexure, and the rectum is for the most part empty. The passage of a portion of the dejecta into the rectum and the vicinity of the sphincter sets up that irritation which by reflex action produces the phenomenon of defecation. If this call is habitually neglected, the sensibility of this portion of the bowel is blunted, so that a great accumulation of fæcal matter may take place. This dilates the bowel and still further obtunds sensibility, so that a vicious circle is established and the evil is increased. Another cause of this condition of things is the lack of a regular habit of defecating at a fixed time daily. It seems possible to train the intestine, as it were, to send its contents into the rectum at a stated time daily; and if this periodicity can be secured, one has a powerful aid toward regular and complete evacuation. From the atony above described one finds various degrees up to paralysis of the peripheral nerve endings in the intestine, and of the centres in the cord presiding over peristalsis and defecation. Again, the atony may not be confined to the unstriped muscles of the intestine, but may affect the voluntary muscles as well. This is especially the case in obese persons, and those having lax, pendulous bellies, as after numerous pregnancies. Deficiency of secretion of the intestinal glands contributes to constipation by lessening the fluidity of the chyle. Over-active absorption of the fluids of the chyle may act in the same way; this occurs in febrile states, and when the perspiration is abundant. Anæmia is usually given as one of the causes of constipation; perhaps it would be truer to say that the two conditions have some causes in common; among them an indoor life and sedentary occupations. Probably a large proportion of individuals engaged in sedentary callings suffer at some time from constipation. This is especially the case in those who have changed their mode of life from a more active one, as in the case of students who have formerly been active bodily workers. Any change in surroundings, even though it do not involve a lack of exercise, may cause constipation, as when a person removes from one climate and soil to another. The change of water very possibly adds to this effect. Most landsmen taking a sea voyage suffer more or less from constipation. Congestion of the mucous membrane of the bowel has sometimes a constipating effect, especially when it is due to chronic venous obstruction. For this reason diseases of the liver involving passive congestion of the portal system are often attended with constipation. The explanation seems to be that long-continued passive congestion leads to thickening of the mucous and submucous coats, which impairs peristalsis.

Some forms of cerebral disease, notably tuberculous meningitis, are attended with constipation to a greater degree than other maladies of like febrile intensity. An important aggravating, if not primary, cause of constipation is the use of cathartics. These are seldom if ever required in the treatment of constipation, laxatives always being preferable to purgatives. But, through a mistaken notion of what is needed, the laity are much addicted to the use of powerful cathartics, which, though they relieve temporarily, in the end aggravate the difficulty. Enormous quantities of cathartic pills, chiefly of the proprietary order, are consumed by the public, and no small proportion of their users arrive at that unfortunate condition when nothing but a repetition of these drastic purges will procure them an evacuation. Improper foods are another cause of constipation; among such we may mention those which are specially concentrated, so that they leave little residuum; a certain bulk of unassimilable residue is necessary for the intestine to act upon. Foods that are too bland, as milk, act in the same way, not affording an irritation sufficient to stimulate peristalsis. This effect of faulty foods is specially observable in young children. Finally, chronic lead-poisoning has among its symptoms marked constipation; here of course, ordinarily, one can obtain the collateral evidence of colic, blue line on the gums, etc.

Much of the importance attaching to constipation depends upon the effects which it produces. Among these that upon the digestive function has been referred to. It is perhaps to the latter that the mental depression so often observed in constipated persons is more directly due; but however this may be, the coexistence of constipation with mental irritability and melancholy is often marked. Intestinal catarrh may be induced by constipation, and may, as already hinted, show itself by a diarrhœa actually coincident with constipation in other parts of the bowel. The catarrhal process occasionally localizes itself, notably about the ileo-cæcal valve; inflammation here (typhlitis) may go on to ulceration, and even perforation, or may by extension cause perityphlitis, with or without ulcers. Other neighboring viscera may suffer from overloaded bowels; a distended and dilated rectum may cause uterine congestion, thence proliferation of tissue adds weight and finally causes displacement. More frequently is its aggravation of symptoms due to uterine disease that had an independent causation. Neuralgias, ovarian, and especially of the sciatic nerve, may be determined by constipation. In the male, seminal emissions are sometimes so caused. Hemorrhoids constitute one of the most annoying and serious consequences of constipation, the distention of the hemorrhoidal plexus being evidently aggravated by a loaded rectum. The general effects of the irritation of the blood by the absorption into it of the contents of the lower bowel, through the prolonged exposure of the latter to an absorbing surface, are shown by the fact that repair of traumatic injuries and operative wounds is observed to be delayed when the bowels remain for a long time constipated. From this it seems reasonable to suppose that other vital processes, depending upon a healthy state of the blood, are similarly hindered by habitual inaction of the bowels.

Auto-intoxication has lately come to be recognized as a cause of many diseases, especially of a mental or nervous character.

TREATMENT.—This is often a matter requiring great judgment and patience. Some of the essentials of treatment have been hinted at in what was said of the causes of constipation. Special attention should be paid to the prevention of this trouble in young children, by training them from their earliest years to regular habits in this regard. The person who is suffering from constipation must be enjoined to select a definite hour (if possible, directly after breakfast), when he will be able daily to devote at least fifteen minutes to securing a proper evacuation. This attempt should be made daily, whether the desire is felt or not, and in time the endeavors will gradually become more and more successful. The water-closet should be made comfortable enough, so far as temperature and accessibility are concerned, so that the individual can spend that amount of time in it without danger of taking cold. Unsheltered and exposed privies are a fertile source of constipation in delicate females. After a stool occurs, a few minutes should be given to see if a further amount of fæcal matter finds its way into the rectum, a thing which often happens. It should never be allowed to remain in the rectum, for that will blunt the sensibility of the mucous membrane, and so delay the cure. A call to defecate, no matter when it occurs, should never be neglected for a moment. The "postural" treatment has been recommended, wherein the patient assumes a squatting rather than a sitting attitude, thereby securing a mechanical advantage in the act of defecation. The diet is of great importance to a constipated subject. Fruit is usually of benefit, particularly figs, berries, stewed prunes, and baked apples. Oatmeal has a popular reputation in this regard, though occasionally persons are found upon whom it seems to have a binding effect. Brown bread and molasses are anti-constipative. An orange, or a pear, taken immediately on rising, will sometimes act as a laxative. In infants, after the fifth or sixth month, costiveness is usually an indication for introducing starchy substances into the diet. Among hygienic measures, we mention out-of-door exercise—in particular horseback riding; massage or kneading of the abdomen, which should be practised daily on rising, the manipulation being over the ascending, transverse, and descending colon, in that order. Electricity similarly applied has proved effective. It may be mentioned that tobacco-smoking acts with some persons as a laxative. The ingestion of a considerable amount of water is to be recommended, and a glass taken on an empty stomach in the morning is particularly effective. Mineral waters are, many of them, of value chiefly by attracting patients to ingest large quantities of fluid, which otherwise they would neglect to do. Some mineral waters, of course, have a distinct laxative character by virtue of their dissolved ingredients. Such are Hunyadi János, Friedrichshall, Congress, Carlsbad, Rubinat-Condal, Apenta, etc. Laxative waters that can be drunk on the spot, *i.e.*, among diverting and pleasant scenes and society, are particularly useful. One to five glasses daily, according to the strength of the water, may be required. The drug treatment of constipation always requires caution. Purgatives are almost never indicated, except, perhaps, once at the beginning of a course of treatment. Laxatives in the form of mineral waters, just alluded to, or as salines, magnesia, potassii et sodii tartras, etc., may be given in small repeated doses if necessary. Probably no better drug exists for the treatment of chronic constipation than aloes, which acts specially on the lower bowel, and but little upon the secretions. This should be given in small doses (say 0.01 to 0.02 gm., gr. $\frac{1}{6}$ to $\frac{1}{3}$ in pill; two pills to be taken two or three times a day). Unlike other cathartics, this does not require to be increased in dose to maintain its effect, but one pill can be dropped at a time till the motions are natural. Belladonna in the form of the extract, 0.01 to 0.15 gm. (gr. $\frac{1}{6}$ to $\frac{1}{4}$), once or twice a day, is highly recommended by Trousseau. Nux vomica and strychnine have given good results, but are most reliable when combined with other remedies. They act not as cathartics, but probably by increasing the reflex irritability of the spinal centres which preside over peristalsis. The buckthorn (*Rhamnus frangula, R. purshiana*, etc.) has been advocated, and the cascara sagrada, in the form of the fluid extract, in doses of 2 gm. and over (ʒ ss.), seems to be a valuable addition to the therapeutics of constipation. The latter drug is also used in the more palatable form of compressed tablets, with or without aloin and nux vomica. Cold- or hot-water injections may be practised daily as an adjuvant to other treatment; suppositories of glycerin or of soap immersed in oil are sometimes effective, especially in children. Finally, in cases of obstinate rectal impaction, mechanical removal of the fæces by the finger or by a scoop may be necessary. *Charles F. Withington.*

CONSUMPTION, CLIMATIC RELATIONS OF.—From the period when *De aëribus, aquis et locis* was written to the present time, when each year sees a number of new publications devoted to the special virtues of particular *health resorts*, it has been generally accounted true that Hippocrates was right when he wrote, "Whoever desires to understand medicine thoroughly can by no means neglect the study of the seasons with their variations, of the winds, both as to heat and cold, and those peculiar to certain regions, and of the properties of different waters." The bearing of these words has, by writers of every age, both historical and scientific, been noticed in connection with diseases in general, but especially with regard to phthisis, which has prevailed among every race of men of whose history we have authentic records. At the present day, so frequently do we read and hear of one region after another being free from consumption, and of this and that *health resort* being veritable *air cures* for tuberculosis, that, could we accept the statements of their advocates, "the conclusion would follow that wellnigh all of them are detached fragments of the original Paradise, replete with all that can make life enjoyable, and walled round from the incursions of death." Dr. W. H. Walsh says: "Probably the earth offers few known spots more favorable to the tuberculized British patient than Nubia; yet the native Nubians on their own soil are occasionally destroyed by phthisis." New Zealand is popularly believed to give perfect immunity from phthisis, and yet rheumatism and pneumonia prevail there, and partial mortality returns give more than ten per cent. of deaths as being caused by consumption. Dr. E. M. Wight writes of the inhabitants of the Cumberland tableland in Eastern Tennessee, as a "people without consumption"; while local physicians sing the praises of the Laurentide forest and lake region of Northern Ontario, as having a Canadian population free from phthisis. So the records read, but actual facts cruelly banish the illusion, and, concerning them all, we have finally to admit the truth of the statement of Dr. Bennett, who, while praising the towns of the Riviera, is yet forced to say: "The perpetual spring, the eternal summer, the warm, southern, balmy atmosphere described to the reader in such glowing terms, only exist in the imagination of the writers."

While, however, it is well to admit at the outset that perfection of climate, as regards immunity from consumption, is not to be expected, there has, nevertheless, been too much taught us by the healthfulness of the inhabitants of, and by the experience of invalids in, regions having certain climatic characteristics, to prevent us perceiving that there are certain meteorological conditions more conducive to freedom from phthisis than are others; and it will be our aim to point out what these are, and where they exist in highest perfection. The opinion of Hippocrates, thousands of years old, regarding diseases in general, was but repeated and added to by Mr. John Simon, C.B., Chief Medical Officer of the Local Government Board of Great Britain, when, in 1867, he wrote: "That vastly fatal disease [phthisis], if we are to have proper knowledge of its causes, must be studied from many different points of view." His investigations show it to be a disease "which undergoes development in proportion as men are *unwholesomely gathered together in in-door industries*"; and again he says, "it is shown to be a disease which develops itself in proportion as *men are dwelling upon a humid soil.*" Dr. H. I. Bowditch, of Boston, arrived at a similar conclusion as long ago as 1862, regarding the intimate connection between dampness of soil and the prevalence of consumption; and the Secretary of the Provincial Board of Health, Ontario, Canada, has pointed out that in two contiguous health districts of the province, one of which is a plateau, and notably free from malaria, and the other, a flat, malarious district, the deaths from consumption in 1881 were, in the first, 8.5 per cent. of all deaths, or 1.02 per 1,000; and in the other, 12.7 per cent., or 1.64 per 1,000.

From these various statements, based upon statistics, it must be plain that meteorological conditions *per se* form but a part, and apparently a small part, of the factors entering into the question of the causation of consumption. Assuming the truth of these statements, it will be necessary to adopt some comprehensive method of treating the subject, from the evident fact that there are many elements of a heterogeneous character entering into it.

Simon asserts that in discussing the prevalence of phthisis, its *hereditary relations*, and *the nature of the morbid process which accompanies it*, cannot be overlooked. Within more recent years, however, as the study of the causation of tuberculosis has become more exact, most authorities are agreed that while the hereditary element in the disease cannot be neglected, a clear distinction must be made between cause and tendency. The general dissemination of tuberculosis, its chronic character and the great vitality of its germ, make infection more widely distributed than that of any other disease; and hence it is that persons inheriting a taint or vicious quality of tissue as the scrofulous habit, or living under conditions affecting the vital resistance of tissues, are especially liable to contract this as any other communicable disease, when exposed to infection.

This being the case, it is apparent that there are briefly to be considered:

1. The nature of the cause.
2. How its development is aided by (*a*) heredity, (*b*) vitiated air, (*c*) moisture of soil, and (*d*) atmospheric conditions.
3. The climatic conditions counteracting its development, and favoring a return to health of the phthisical.

1. The Nature of the Cause.—Assuming that until experiments, greatly more extended than have yet been instituted, shall have proved the incorrectness of the zymotic theory of tuberculosis, it may be taken as established, and hence the qualities of the *Bacillus tuberculosis* in relation to external influences affecting its development may be noticed. Koch observes that, while the sputum of tuberculized patients almost invariably contains bacilli, and that very frequently these bear *spores*, the former existing external to the body for many days, and the latter for many months, yet they are not likely to be borne on the air until they have become desiccated. This tends to the destruction of such vegetable cells, but their destruction is especially favored by the action of sunlight, experiments such as those of Marshall Ward and Büchner going to show that this destructive action depends especially upon the ultra-violet rays of sunlight, causing a destructive oxidizing action to take place on the cells. Owing to this sensibility to light and temperature, their growth requiring a temperature between 29° and 42° C. (85° and 108° F.), and their fastidiousness as to the composition of the soil, the important conclusion as regards infection is arrived at, *that the bacilli of tuberculosis are limited to a parasitic mode of life in animals, and cannot grow outside of the body under the conditions found in nature.* It has further been established that the inhalation of a spray, containing bacilli in suspension, by guinea-pigs, rats, and mice, inoculates these various animals with the disease, and that the extent of the tuberculization depends on the length of time between their inoculation and death. From the peculiarities of the Bacillus tuberculosis as regards its development, it becomes evident how little infectious the disease is, compared with some other zymotics, and how the spread of the disease is made possible, almost wholly, by the inhalation of the atmosphere of apartments which the phthisical have inhabited.

2. How the Development of the Cause is Aided.—That there are conditions favoring the development of tubercle there can be little doubt, and among these in this connection may be mentioned—

(*a*) *Heredity.*—Koch tells us that the character of the pathological lesions depends on the number and localization of the bacilli, and on the power of resistance of the tissues of the patient. Dr. H. F. Formad illustrates this difference in power to resist by asserting that the scrofulous habit, or a tending to take on a tuberculous inflammation, exists in certain animals, as rabbits, etc., through a structural narrowness of the lymph spaces of the connective tissue, and that similar tissue exists in scrofulous individuals. Dr. Jonathan Hutchinson, of London, maintained for years the position that the bacillus of tuberculosis is directly transmitted to the infant *in utero*, and that it may under certain conditions lie dormant in the tissues. Professor Bang, of Copenhagen, estimates this transmission at one per cent. in calves from tuberculous mothers; but perhaps as much as can be said with such isolated facts before us is that clinical evidence in this, as in many other diseases, as well as *inoculation* experiments, has placed the fact beyond doubt of there being a relative susceptibility or insusceptibility to infection, or, in other words, *hereditary* and *induced* tendency to disease.

(*b*) *Vitiated Air.*—It is hardly necessary to draw the conclusion, justified by the qualities of Bacillus tuberculosis, that the impure atmosphere of crowded apartments where consumptives are present must receive and retain greater numbers of bacilli than if it were frequently renewed, and that those exposed will be more likely to inhale them. There are other elements, however, which greatly promote the inoculation of the inmates of such apartments. The insufficiency of oxygen, the excess of carbonic acid, and the volatile emanations from those inhabiting the place, and the frequently vitiating action on the lungs of air containing much dust and insufficient moisture, all tend to induce anæmia, catarrh, and other derangements, which not only lessen the resisting power of the system to disease, but also, by colds and catarrh causing congestion of the mucous tract, produce just such conditions as form a *nidus* favorable for the reception and subsequent growth of Bacillus tuberculosis. The antithesis of this condition is the external air of even cities, which is purity itself when compared with indoor air; while the reconstructive effects of free country air and sunlight are the elements to which we now chiefly look for resistance to the disease.

(*c*) *Moisture of Soil.*—Of all the climatic conditions which promote phthisis Dr. Buchanan's investigations show this to be the greatest. Thus he found that after the completion of improved systems of land drainage, the percentage of deaths from phthisis in every town whose statistics are given decreased; this decrease amounting in some, as Ely and Rugby, to forty-seven and forty-three per cent. This remarkable decrease being the result of drainage, it becomes of interest to consider its *modus operandi.* Dr. Th. J. Turner, formerly Medical Inspector, U. S. N., has abundantly shown the influence of damp air on the health by comparing the sickness and death rates, especially from consumption, on vessels in the United States and British navies, in some of which the old custom of daily washing down the decks was practised, while in others this was performed much less frequently. He asserts that breathing the impure damp air has been the chief cause of phthisis; and that it is the damp air, rather than the limited amount of air, is shown from the fact that the air space per man in both classes of vessels was much the same. Sir Alexander Armstrong, of the British navy, says: "There can be no more fertile source of disease among seamen or, indeed, other persons, than the constant inhalation of a moist atmosphere, whether sleeping or waking; but particularly is this influence injurious when the moisture exists between the ship's decks, where it may be at the same time more or less impure, and hot or cold, according to circumstances." While doubtless the truth of the statistics of Buchanan and Turner illustrates a fact of extreme importance, yet the experimental work of recent years would seem to supply the explanation of the fact in a manner somewhat different from that understood at the time by these writers. In both cases we see damp atmospheres confined in spaces where the influence of sunlight is impossible, and where while the bacilli of tuberculosis may not develop, yet when introduced the conditions favorable to their vitality are present, whether in the cellar or spaces under floors and in the holds of ships. Moreover, in both cases decomposition of organic matters goes on, and morbific germs and the gases produced by them are ever present to lower vital resistance to the specific germs of this disease when once introduced.

Inasmuch, however, as the bulk of population live on the land, it is necessary to inquire into the influences affecting them in this regard. Ordinarily it may be considered that the relative humidity of the air for health should lie between 70 and 75, at the ordinary temperature of 66° F. When it is greater than this, as with a damp soil and low temperature, the heat is very rapidly abstracted, the action of the skin in its secretion of urea and carbonic acid is checked, and the internal organs, and notably the lungs and air passages, are congested, having increased work thrown upon them, and are, moreover, subjected to the same chilling influences as the skin. Hence colds and catarrhs are generated, and conditions favorable, as we have seen, to the development of the specific bacillus are produced.

That damp soil serves to keep the superambient atmosphere damp is seen in the fact that drainage raises the temperature of the soil, and, therefore, of the contiguous air. This has been proved by Parkes, who found that the mean average temperature of thirty-seven experiments gave, at seven inches below the surface, an increase of 10° F. in a drained and cultivated soil over that at the same depth in an adjacent bog. The wet land remains cold on account of evaporation from it producing cold, as water has a high radiating power and a high specific heat, and through the conduction of heat downward in a soil, deprived of a circulation of air, taking place slowly.

Inasmuch as every increase of about 20° F. of temperature doubles the capacity of air for moisture, it is not difficult to see how the soil, by keeping the contiguous air at a low temperature, must to the same extent keep it damp by lessening its capacity for moisture, and thereby produce the evils already referred to.*

When it is remembered that the inhabitants of wet lands habitually breathe an atmosphere saturated with moisture, that their sleeping-rooms are cold and damp, that such dampness renders the air of their unventilated living apartments more likely to retain suspended in it any volatile and organic matters that may be present, and finally that all these factors tend to diminish their resisting powers, it must be confessed that such a combination of conditions must favor in a high degree the successful implantation and development of the germs of tuberculosis in the people who are thus unduly exposed.

Other atmospheric conditions dependent upon the moisture of the atmosphere may be mentioned here. One of these is that the diathermancy of the air is increased or diminished according as the air has little or much moisture in it; and that proportionately to the diathermancy the day temperature rises rapidly, and the night temperature, through radiation, falls just as rapidly. Thus Denver, at 5,200 feet of altitude, shows an average daily range of 30° F., and even with this difference dew but seldom forms. Though this latter fact will indicate the low relative humidity of the air, there can be but little doubt that such extreme and sudden changes must injuriously affect persons other than the most robust. At these high-altitude *health resorts* it is carefully ordered that consumptives either wrap themselves well before remaining out in the night air, or remain within doors or under shelter during the evening. Notwithstanding these, the greatest drawbacks to such dry climates, the fact nevertheless remains that a comparatively small change of temperature in a moist atmosphere produces subjective sensations often greater than do much greater changes where the air is dry. Though under ordinary circumstances it can hardly be said that hot climates are favorable to phthisis, yet it may well be that the endeavors made to keep the body cool by seeking out shady retreats and protecting their houses by trees to shelter them from the sun's rays, create damp atmospheres in the latter, which, through favoring fungoid growth, may promote phthisical tendencies in the population.

3. THE CLIMATIC CONDITIONS COUNTERACTING THE DEVELOPMENT OF CONSUMPTION, AND FAVORING A RETURN TO HEALTH.—The nature of the cause of the disease indicates, in great measure, in which direction these favorable conditions must be looked for. Most writers, in their remarks on the failure of all climates to produce a cure in cases of consumption, have failed sufficiently to discriminate between *hereditary* and *induced*

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* Too painfully accurate is the distich from "Morte d'Arthur"—

> "The white mist like a face cloth to the face
> Clung to the dead earth, and the land was still."

phthisis. It is manifestly unfair to expect that any influence, such as a perfect climate—were such to be found—would be sufficient to undo what generations have produced of imperfect structural development of tissue; and, on the other hand, before pronouncing against *air cures* for consumption, it is only just to weigh carefully the influences under which people, *not affected with consumption*, have lived. When, in the latter case, it is found that such people have lived in a climate which made an out-door life almost perennially possible, and when their occupation has been either pastoral or agricultural, it becomes apparent that we have the plainest rules set forth to guide us, both for the prevention and treatment of consumption. Though experience has shown that no climate can be called perfect in regard to every condition, yet a careful analysis of the reports of the many *air cures* and other health resorts indicate very clearly the special qualities we are to look for in those climates which are favorable to the prevention or treatment of consumptive diseases.

Of these qualities the following, viz., *purity, dryness, temperateness*, and *brightness*, may be considered the most important. It is unnecessary to point out that these four qualities of the atmosphere of a healthy climate are intimately related in their causes, one to the other, since no one quality of climate can be discussed in other than a relative sense.

(*a*) *Purity of the Atmosphere.*—This not only means that the air ought to contain the normal amounts of its two principal constituents, but also that there shall not be an undue amount of carbonic acid in it, since this serves but to indicate the presence of large amounts of organic matters undergoing combustion. [An exception to this rule may be pointed out in the case where the air, at considerable mountain heights, according to Prof. R. Angus Smith, contains more than the usual amount of carbonic acid. In this case it may fairly be assumed that the excess is due rather to a rapid oxidation of existing organic matter than to its amount being greater than that on lower levels.] From this gauge of purity it follows that the air of badly ventilated rooms, of the cabins, and especially the berths of ordinary vessels, of all except the openest and cleanest of towns, and of that in proximity to marshes and other large deposits of decaying vegetable matter, must be equally avoided, since each instance indicates the progress of organic combustion, due to either chemical, physiological, or zymotic agency. The latter form of combustion is of great importance in this connection, since it is indicative of conditions favorable to the development of the Bacillus tuberculosis. From these considerations open spaces, as in the open fields of most cultivated districts, in inland localities with dry soil and good sanitary surroundings, and especially those situated at a relatively low elevation—*e. g.*, areas which have a light rainfall and possess a mountain climate—are the places to be sought out by the phthisical.

(*b*) *Dryness of the Atmosphere.*—If it be true that purity of air is one of the essential conditions if consumption is not to be produced, it is just as true that dryness of the atmosphere is one of the conditions upon which we have to depend for retarding the progress, and, much more, for effecting the cure of the disease in its early stages. These curative conditions are not only freedom from the dampness of the soil, but also the direct effects of dry air upon the tuberculizing process in the lungs. These latter are seen in the experience of the phthisical in high altitude climates, as that of Davos and Colorado, from which it would appear that—owing either to the diminished irritation produced by such dry air or to the decreased activity of the tubercle bacilli—there is less secretion from the respiratory mucous membranes. As stated by a gentleman recently living in Colorado: "Expectoration is usually less here than in the East; I suppose first on account of dryness, and second on account of a peculiar mildness or balminess of the air. My tender throat seldom feels here that raw, rasping damp air that one gets in England and the East. . . . We seldom have dew here; had more in Davos, I think." It is also a matter of universal experience that people resist the cold better in dry, even though at very low temperatures, than in moist atmospheres.

(*c*) *Temperateness of the Atmosphere.*—By this it is understood, first, that a climate ought not to be subject to great extremes of heat or cold; and, second, that the changes from heat to cold, or *vice versâ*, ought not to be either rapid or extreme. The experience of robust persons residing long in India, or subtropical America, shows the debilitating effects of great heat on the physical system; while the sufferings of delicate people in cold climates indicate the strain produced by low temperatures. Frequent and extreme changes are, however, the special points of interest in relation to temperate climates, since on these must greatly depend the relative humidity of any locality. From Glaisher's tables it appears that the capacity of a given volume of air is doubled for about every 20° F. of increase in temperature; from which it follows that an atmosphere which at noon, with a temperature of 70° F., shows a relative humidity of 50, will, at sundown, with a temperature of 50° F., be saturated; or if, as is often the case, the relative humidity at noon be 75, saturation point will be reached as the temperature approaches 60° F. If we remember that it is radiation of the earth's heat with the declining sun that lowers the temperature, and that this radiation, as well as the amount of heat absorbed by the earth during the day, is largely regulated by the amount of vapor in the atmosphere, it is perfectly plain that we must expect rapid and great daily changes in dry climates, and much less rapid changes in moist climates. From these considerations it must be apparent that tables of mean annual relative humidities, as ordinarily given in works on special health resorts, have no practical value in determining the fitness of a locality for consumptives.

These facts being kept in view, it becomes a matter for careful study to determine wherein lies the happy mean between dry climates, with great daily range, and moist climates, with small daily range of temperature. In a general way, it may be said, that between the two extremes lie the conditions most favorable to health. The experience of persons on arid wastes, and in rooms which, ill-ventilated, are heated by hot-air furnaces, without any means for supplying moist air, shows that there is a limit at which dry air becomes inimical to health from its irritating qualities, and by its abstracting moisture from the mucous membrane. The injurious effects of damp air are too well known to require illustration here.

Before leaving the question of the *temperateness of the atmosphere*, some remarks are required regarding the influence of winds on health. They may most properly be considered here from their power to affect the temperature of the body. That they play a most important part in purifying the atmosphere cannot be doubted, while the fact that they are promotive of health, through the pleasant sensations they may produce, is equally evident. But their beneficent influences are dependent upon their degree of temperature, moisture, and their force. As regards temperature, it is well known that winds of low temperature are injurious in proportion to their force, from the rapidity with which they abstract heat from the body. So marked is this fact that the degree of reduction of temperature compared with the force of wind has become the subject of experiment, and has been reduced to a definite law. Colonel Charles Smart, Assistant Surgeon-General, U. S. Army, has determined the rate at which the mercury of a thermometer falls in the calm from a standard temperature, when subjected to different degrees of temperature for given lengths of time; and, also, the increased rate of *fall* when exposed to certain temperatures, *plus wind and moisture.* Thus, the ratio borne by the fall *when exposed to wind*, as compared with the fall *in the calm*, the latter being taken as unity, is:

Wind	at ¼	mile	per hour	increases	*fall*	1.42	over	1.00.
"	1	"	"	"	"	1.71	"	1.00.
"	5	"	"	"	"	2.63	"	1.00.
"	10	"	"	"	"	3.18	"	1.00.
"	14	"	"	"	"	3.39	"	1.00.
"	20	"	"	.	"	3.60	"	1.00.

The moisture in this case is not estimated in its effects, but it is a factor of extreme importance in the reduction of temperature. Heat is abstracted not only in proportion to the force of the wind, but also in proportion to its degree of moisture, for the reasons mentioned in connection with moisture in general. The force of the wind further becomes, at certain health resorts in certain seasons, a source of injury to consumptives, from its causing clouds of dust and sand to be blown along, which, being inhaled, become very irritating to affected lungs. Such effects are said to be especially noticeable in those reputed resorts of consumptives, Australia, Cape Colony, Arizona, and Southern California, and have been mentioned by Marcet as being the cause of sore throats during dry days at Cannes. From facts such as the foregoing, it is apparent that the prevalence of certain winds must affect very greatly the character of the climate of different localities, as regards their claim to being health resorts.

(*d*) *Brightness of the Atmosphere.*—This quality, which in large measure bears a direct relation to dryness, must for several reasons be considered an important element in its bearings on the subject. That the amount of sunshine is not always the gauge of the healthfulness of any locality, is seen in the mortality and disease statistics of temperate North American regions; since from some of these it appears that November is among the healthiest months of the year, although having the smallest amount of sunshine. The absence in some measure of winds, such as those of March, and the low average daily range of temperature, must be credited with this favorable result.

Brightness, or diathermancy of the air, which is used to express the intensity of sunshine, may be said to be in direct proportion to the relative humidity of the air. From Jourdanet's and Denison's tables it appears that the intensity of sunshine increases directly with the altitude. This intensity is measured by the difference between the temperature in *sun* and in *shade*, and has been represented by the following rule of Denison, viz.: *One degree greater difference between temperature in sun and shade for each rise of 235 feet.* The experiments of many others, as Piazzi Smyth on the Peak of Teneriffe, and of Vacher and others at Davos, abundantly prove the intensity of the sun's rays in high altitudes. This intensity, as is readily understood, is associated with the fact that there is sunshine in such localities on almost every day throughout the year. That sunshine has, when the heat is not too great, most beneficial effects upon man, as upon most living animals, is too commonplace a remark to require reasserting. Some of the ways by which such good influences are exerted are well known. Dr. Thaon, in his "Clinique Climatologique," has well summarized these influences. He remarks that solar heat increases all the functions of animal as well as vegetable life; the blood circulates with greater rapidity, respiration is increased, peripheral circulation is more active to the advantage of internal organs, which thus free themselves from stagnant blood charged with excrementitious principles. Light, also, as seen in vegetation, plays a most important part through its active rays. "It reddens the blood, it cures chlorosis in the same manner as it restores the color to plants bleached in darkness."

Slight consideration must make it apparent that the numberless variations in the combinations of these factors cannot fail to create climates with equally varying characteristics; nor can we fail to remark that the same locality throughout the year is subject to equally numerous changes in the combinations. Further, when it is remembered that the conditions of phthisical persons, depending upon *hereditary* or *induced* causes, are infinite in their differences, we are not surprised that the question of what climate will best suit individual cases becomes of extreme difficulty as well as importance.

The sex of persons, their ages, their education and tastes, their companionships, their attendants, their pecuniary abilities, the progress of the disease, etc., may all be questions equal in importance to that of climate, if not even more important—so susceptible is the physical well-being to æsthetic and psychical influences.

The question of climate as regards the prevention of phthisis is of greater importance by far than that regarding its cure. Experience has shown that in every climate consumption has increased with the increasing population, and therefore the first step in its prevention, as in its cure, is to see that the sanitary surroundings of people in their homes, and when employed in their daily vocations, are of the most perfect nature possible. But inasmuch as it has become the *mode* to draw distinctions between climates fitted for the phthisical at different stages, it will not be improper for us to give some directions which experience has proven to be of some value in the treatment of consumption.

In all early stages of the disease, before hæmoptysis has occurred, bright, dry climates, where the air is invigorating, as at varying heights rising to five thousand feet above the sea, where the rarefied air allows of greater lung expansion, and where life with active exercise in the open air may be engaged in, are those which seem likely to produce most gratifying results. Owing, however, to the extreme daily range of temperature, protection from the night air in well-ventilated dwellings or in tents is markedly indicated. That height is probably not the necessary element in the cure, except so far as it is the gauge of brightness and dryness, is seen in the almost uniformly good effects of *surveying* and *camping out* in the bracing air of the Northwestern prairies, as of Montana and the British Territories. Such, too, are the experiences of consumptives at the far-famed health resorts of the whole Riviera in the winter season. When pronounced hæmoptysis has taken place both theory and experience contraindicate treatment by high altitudes, with their rarefied air, unless by the most gradual ascents. Jaccoud illustrates the first by patients going to the mountains direct by rail from Paris, only to have a hemorrhage occur on their arrival,—a hemorrhage, however, which ceases immediately on their descending again. Dr. Paul Regnard has given statistics greatly qualifying the tendency as stated by Jaccoud. In such cases the bracing air of the Northwestern prairies would seem to be of the greatest value. When the disease progresses but slowly, high altitudes with their tonic influences and effects upon digestion and nutrition do produce good effects. In cases with much cough and bronchitis, the inland lake districts on the Laurentides of Canada, with their immense evergreen forests of cedar, hemlock, and pine, supply conditions eminently tonic and soothing. The temperature is equalized by the evaporation from the lakes, and the trees diminish the violence of the winds. Then, besides, the cool waters which flow from the northern watershed into the innumerable small lake basins make the air cool and invigorating in the midst of summer, and afford the opportunities for camp life, with unlimited facilities for fishing and hunting, thus giving variety and exercise without the danger of fatigue, so often incident to hill climbing. The average height of these lakes is about one thousand feet above the sea.

Reference has been made to purity, dryness, and brightness as being the chief elements that give therapeutic qualities to the atmosphere; and that these qualities usually exist in their highest degree in mountain climates has been indicated by experimental work made during the past ten years by numerous workers, which has added much to our knowledge of the physiological changes going on at high altitudes. The most comprehensive exposition of this work and the conclusions based upon it is that by Dr. Paul Regnard, Paris. Similar conclusions are set forth by Dr. Solly, Colorado Springs, in his recent work. These with other competent observers insist that tuberculosis practically does not exist in high altitudes except when introduced, and Regnard, summing up the reasons for this, says:

1. That Freudenrich affirms that the rarity of the bacillus is due to the degeneration induced in this organism by its life in cold atmospheres for many months—a fact proven experimentally.

2. That persons rich in blood constituents are seldom inoculated with the disease, its onset depending upon anæmia and general depreciation of the health, and that these conditions but seldom prevail in mountain climates, owing to the fact that the blood, at these high altitudes, is richer in red corpuscles than it normally is at low levels.

3. That while a cold fresh air prevails in the mountains even in the summer, there is the additional fact that in winter mountain atmosphere is fresh and dry with sunshine of great intensity.

When the change of residence is first made from a low level to that of a mountain resort the individual is likely to experience what is known as the *maladie de la Montagne,* the symptoms of which are heat sensations, turgidity of lips and conjunctiva, with flushed face, nosebleeding, sleeplessness, breathlessness, headache, and vertigo. This is rapidly followed by improved appetite, a sensation of *bien-être,* improved spirits, decrease of nervousness and dyspnœa. The first symptoms were due, according to Regnard, to an anoxæmia and the physiological needs created by this condition. Under the stimulus of this demand for more oxygen a condition of hyperhæmoglobinæmia soon becomes established. In other words, the blood of anæmic persons who transfer their residence from a low to a high altitude will soon contain the amount of oxygen which a fairly healthy person would possess at the lower level, and this can only be attained through an increase in the number of red blood corpuscles; for experiments on animals subjected for weeks to atmospheres of reduced atmospheric pressure show that the capacity of red corpuscles to hold oxygen varies directly with the decreased pressure or with elevation above sea level. The corpuscles will rise in number from a normal at sea level of 4,000,000 per cubic millimetre of blood to 6,000,000 or 7,000,000, according to height, within a fortnight. Paul Bert's law is thus expressed:—If at 760 mm. (30 ins. on barometer) blood absorbs 20 c.c. of oxygen, at 370 mm. it absorbs only 16.5 c.c., and at 30 mm. it absorbs only 7.4 c.c.

Regnard, after a review of the experimental evidence regarding nutrition, the changes in the composition of the atmosphere and the increased hæmatopoiesis having an intimate relation to it, says that when the atmospheric pressure diminishes, the oxygen supplied for organic combustion diminishes. Then the red corpuscles begin to increase, and soon the normal condition of tissues is restored and even passes the normal. It is certain, then, that in the mountains the appetite, stimulated by the fresh air and walking, determines a more active nutrition and more intense combustion. Similarly, there is an excess in the moisture given off in the mountains by pulmonary respiration. Probably, however, there is a tendency to increase in weight by residence in the mountains.

Much may be said concerning the stimulating influences derived from the ozonized air and the salt breezes blowing from the ocean. These must, however, be associated with a mild air, otherwise the dampness and fogs of the coast cannot fail to injure all except early cases of consumption, in which general debility is chiefly present. In such cases the coast from Boston southward during the summer, and the Gulf of Mexico during the winter, seem to best fulfil the indications. Los Angeles, etc., on the Pacific coast may, with good cause, be considered in this connection. The equable character given to the climate of the Pacific coast by the *return equatorial current* flowing from the north to join the parent stream at the equator, has of recent years given it many claims to prominence in the treatment of consumption. In many respects the climate of Southern California supplies America with a resort in a fair way of becoming as celebrated a winter residence for invalids as the far-famed Riviera of the Mediterranean; and, if lacking in some of the historic interest attaching to the latter, it certainly surpasses it in a freedom from the unsanitary conditions too often present in these old towns.

Any attempt to enumerate the almost infinite number of health resorts whose special claims have, even in America, but especially in France, Italy, Germany, Spain, England, Scotland, Switzerland, Algiers, Australia, and Tasmania, been set forth by special advocates, would be as impossible as it would be unscientific; and it is only by a careful review of the many conditions in connection with each case that satisfactory results are at all likely to be arrived at as regards its treatment.

P. H. Bryce.

CONTAGION. See *Infectious Diseases.*

CONTRACTILITY, CONTRACTION.—Contractility is one of the fundamental and inherent properties of living matter. Nearly all of the movements which are so characteristic of living nature are due to this property; that is, they are due to the contraction of protoplasm.

The contraction of a body or of a substance implies an alternating compensatory expansion or relaxation. If it were not for the alternating contraction and expansion (or relaxation), a repetition of a movement could not occur, and the end for which contractility seems to exist could not be accomplished.

Contraction is active, while relaxation is passive. Contraction can be accomplished only through a catabolism of the living substance, while relaxation involves no catabolism and may take place at the same time with anabolism.

I. THE SIGNIFICANCE OF CONTRACTILITY.—Contractility in its most primitive form is possessed by the active protoplasm of unicellular plants and animals. In a more advanced form it is the property of more or less specialized portions of the metaphyta and of the metazoa. The active protoplasm of higher plants forms so small a portion of the plant body, and the activities of this portion are so obscured by the more prominent and apparent portions of the plant, that one is likely altogether to lose sight of the importance of contractility in the plant kingdom.

On the other hand, the extreme prominence of this property and of the highly specialized muscular tissue which manifests it in the higher animals leads the casual observer to associate contractility with the animals, and to look upon it as one of the characteristics distinguishing animals from plants.

Being an inherent property of living matter, contractility must have a significance which bears a fundamental relation to life.

Only through the study of primitive forms can one elucidate these problems of life. Let us suppose that one has before him under a microscope an amœba just taken from an aquarium (Fig. 1499). When first seen under these conditions the organism is likely to be a fairly compact subspherical grayish mass. Presently one sees a portion of the mass slowly extending out from the main body. Other portions may extend out in other directions. These extensions or pseudopodia seem to be feelers. Through them the organism seems to get information regarding its immediate environment. Presently one of the pseudopodia gets rapidly larger through a

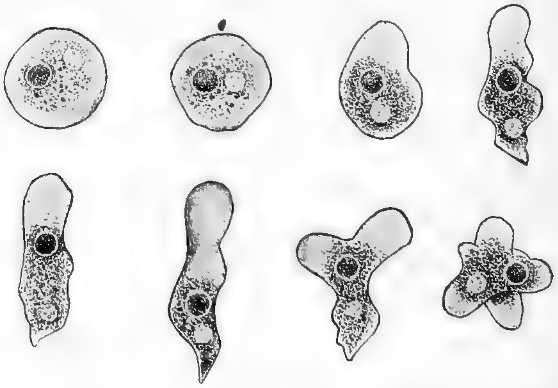

FIG. 1499.—Showing Various Phases of Amœboid Movement.

flowing of the protoplasm into the growing pseudopodium from the cell body and its other extensions. In this way the organism moves across the field.

Should it by accident or otherwise come in contact, at any part of its periphery, with a small solid body, such as a unicellular plant of smaller dimensions than itself, it immediately flows around the foreign body, thus engulfing it. A plant body thus engulfed or swallowed is actually digested and assimilated by the amœba.

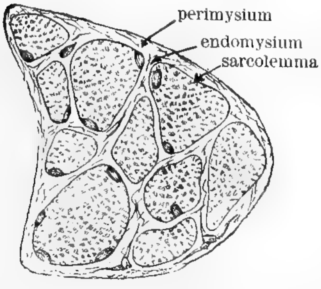

FIG. 1500.—Cross-Section of a Fasciculus of Muscle. Note that each muscle fasciculus is surrounded by a sheath called the perimysium; that the fibres which constitute a fasciculus are separated from one another by endomysium, and that each fibre is surrounded by a cell wall called the sarcolemma. The dots just within the sarcolemma represent nuclei.

If the glass slide upon which the organism is resting be jarred, or if in any way the animal is suddenly stimulated, it quickly draws up in a spherical mass, and remains thus contracted until everything is quiet and the way seems clear for another reconnoitring of the environment—another foraging tour.

Finally, after a preliminary period of rest the old amœba divides into two young ones, thus completely merging its individuality into that of the succeeding generation. This act of reproduction is accomplished through the means of a certain amount of contraction and movement.

The foregoing is, of course, an interpretation of the movements of the amœba in terms of the known activities of the higher animals, especially of man. How far this is justifiable is, of course, a question; but if we interpret the actions of low organisms at all we must of necessity do so in terms of our own experience.

Accepting this as a basis for our reasoning, we may say, then, that there are three fundamental ends served by the movements of the amœba: (*a*) nutrition; (*b*) protection; (*c*) reproduction.

In serving these three great realms of life activity, contractility stands in most intimate relation to the whole of life. If we study the higher ranks of living nature, we shall find that contractility holds just as important a relation to nutrition, protection, and reproduction as is observed in the protozoan.

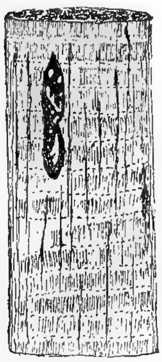

FIG. 1501. — Portion of a Fibre of Human Muscle. Note the transverse bands or striations. The light discs are divided by a dotted line (plane), first described by Krause and supposed by him to be a membrane.

II. THE STRUCTURE OF CONTRACTILE SUBSTANCE.—It has been stated above that all living substance possesses the property of contractility as one of its inherent characteristics. It follows that the discussion of *the structure of contractile substance* is really the discussion of the structure of *living substance.* It is the intention of the writer to discuss in detail only those features of protoplasmic structure which are of especial significance in contractility.

Beginning with that substance which is most highly specialized as to contractility, viz., muscle tissue, one notes that the cell is a fibre and that the cell substance is fibrillated. In action it is observed that the cell becomes shortened in its long axis while its lateral dimensions increase, the volume remaining the same. The shortening of the muscle fibre (cell) is universally conceded to be the result of the shortening of the fibrillæ, which take a prominent part in the structure of each muscle cell.

Each fibre or cell is surrounded by a delicate cell wall, the *sarcolemma*, shown in Fig. 1500.

In the figure the shaded areas (areas of Cohnheim) into which the cross-section of each fibre is divided, represent bundles of fibrillæ, *muscle columns*, which are separated by the sarcoplasm.

The proportion of sarcoplasm to fibrillar substance may vary enormously in the muscles of different species as well as in the different muscles of the same animals. "Those muscle fibres which serve the most persistent or most strenuous actions are richest in sarcoplasm." "The great pectoral muscle of the best fliers (among the birds) consists exclusively, or almost exclusively, of plasmic (rich in sarcoplasm) fibres, while in the weak-winged fowls it consists predominantly of aplasmic (poor in sarcoplasm) fibres." "There can be no doubt that energetic chemical changes go on in the sarcoplasm, as is proved by the frequent appearance within it of fat drops." "All indications favor the proposition that *the sarcoplasm* furnishes the pabulum which nourishes the fibrillæ during its activity." "If, then, it really is the rôle of the interfibrillar plasma (sarcoplasm) to preside over the nutrition of the contractile substance, the greater abundance of sarcoplasm in the muscles which serve the most strenuous and persistent functions is readily intelligible." (Quotations from Biedermann's "Electro-Physiology.")

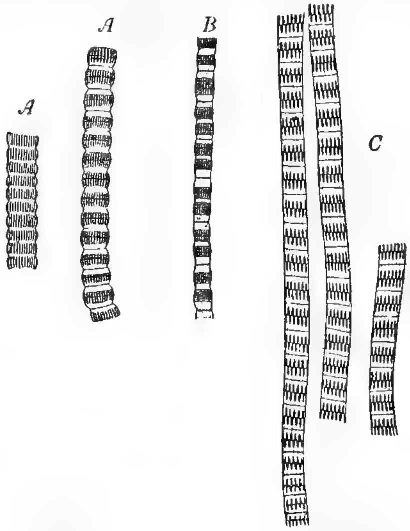

FIG. 1502.—Wing Muscles of an Insect. (After Shäfer.) *A*, Contracted; *B*, same, relaxed; *C*, moderately extended.

The structure of the fibrilla has been under discussion for many years. Many of the points at issue are still unsettled. Fig. 1501 shows a human muscle fibre under high magnification. Note that the fibre presents alternating light and dark bands and that the light bands are subdivided by a fine dotted line. This line is called *Krause's membrane*, because it was at first thought to be a membrane. The whole fibre is composed of a great number of parallel fibrillæ. Each fibrilla is segmented and presents the same alternating dark and light seg-

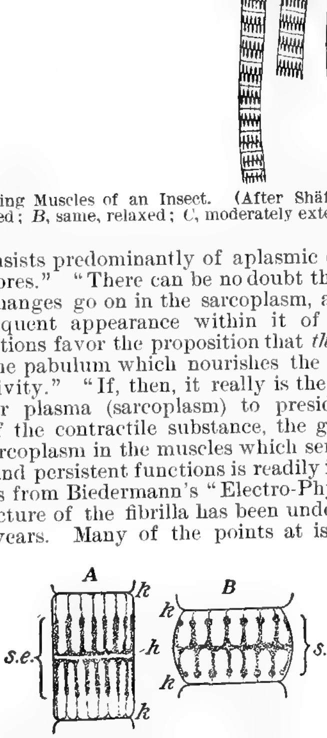

FIG. 1503.—Diagram of a Sarcomere. (After Shäfer.) *A*, Extended; *B*, contracted. The shaded portion of each sarcomere is a sarcosome. *h*, Plane of Hensen; *k*, *k*, membranes of Krause; *s. e.*, poriferous sarcous element.

ments shown by the fibre as a whole. Furthermore, each fibrilla possesses a portion of the "Krause membrane."

The most favorable material for the study of the finer structure of the fibrillæ is presented by the wing muscles of insects. Shäfer's preparations shown in Fig. 1502 give a very good idea of this structure. The portion between two Krause membranes is called a *sarcomere.* Note that in the extended condition the dark band has a light line dividing it transversely; this light line is called the line or plane of Hensen (see Fig. 1503, *A*, *h*). This plane of Hensen disappears when the fibrilla is contracted (see Fig. 1503, *B*, *h*). Each sarcomere then is occupied by dark and light matter. The dark matter seems to be more solid than the light matter. It is called a sarcous element or *sarcosome.*

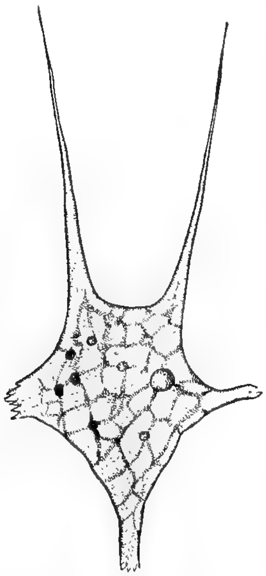
FIG. 1504.—Expanded End of a Foraminifer's Pseudopod. × 3,000. (After Bütschli.)

From the figures given it is evident that the fibrillated structure of muscle protoplasm must play an important rôle in contraction. The attention has already been called to the fact that the muscle cell is composed of fibrillæ and sarcoplasm. Note from Figs. 1502 and 1503 that the fibrilla is, in turn, composed of a darker and a lighter portion, the *sarcosome* and the *sarcolymph.* The sarcosome seems to be of greater consistency—that is, viscous; while the sarcolymph seems to be limpid in consistency. Not all of the substance of the fibrilla is contractile. The sarcosome is actively contractile, while the sarcolymph is passively adapted to the movements of the sarcosome, flowing to and fro in response to pressure from the sarcosome. Biedermann, cited above, has called attention to the fact that it is the sarcoplasm that serves as passive food for the active fibrilla. But within the fibrilla the passive sarcolymph probably serves as food for the active sarcosome.

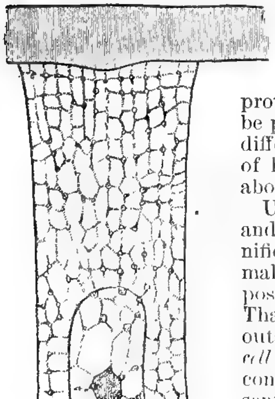
FIG. 1505.—Epidermal Cell of an Earthworm. × 3,000. (After Bütschli.)

In the muscle cell we seem to reach the highest order of differentiation in protoplasmic structure. It will be profitable to study less highly differentiated cells in the search of homologues to the structures above described.

Under favorable conditions and with sufficiently high magnification the protoplasm of animal cells is found to be composed of a meshwork of fibrillæ. That portion of the protoplasm outside of the nucleus, viz., the *cell plasm* or *cytoplasm* is thus composed of substances representing at least two well-defined physical conditions, and belonging, without reasonable doubt, to two categories from a physiological standpoint. The threads or fibrillæ which form the reticulum are of more viscous consistency, while the liquid which fills the meshes of the reticulum is more watery in consistency. The denser thread substance is called *spongioplasm,* while the liquid in the meshes is called *cytolymph.*

A study of Figs. 1504, 1505, and 1506 will reveal all of these features in cells representing a wide range of differentiation in the animal kingdom.

This reticulated structure of protoplasm with its differentiation into spongioplasm and cytolymph is so general and constant that Wilson, of Columbia University, has made a diagram of a typical cell (see Fig. 1507) in which the reticulum in the cytoplasm is a prominent feature. The nucleus, centrosome, plastids, and metaplasm are of importance in any discussion of the cell reproduction and nutrition, but may be passed without further reference at this time.

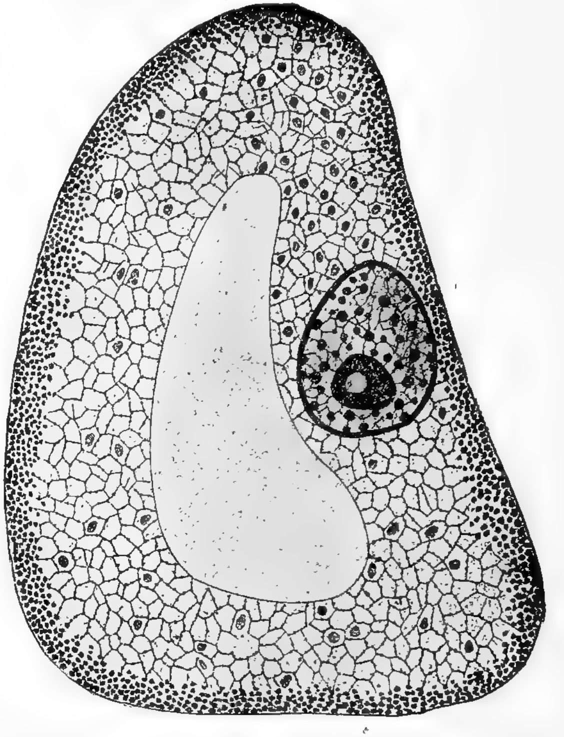
FIG. 1506.—Section through a Nephridial Cell of the Leech, Clepsine. (Drawn by Arnold Graf from one of his own preparations.) The centre of the cell is occupied by a large vacuole, filled with a watery liquid. The cytoplasm forms a very regular and distinct reticulum with scattered microsomes which become very large in the peripheral zone. The larger pale bodies, lying in the ground substance, are excretory granules (*i. e.*, metaplasm). The nucleus, at the right, is surrounded by a thick chromatic membrane, is traversed by a very distinct linin network, contains numerous scattered chromatin granules, and a single large nucleolus within which is a vacuole. Above are two isolated nuclei showing nucleoli and chromatin granules suspended on the linin threads. (Wilson: "The Cell, in Development and Inheritance," 1896.)

There can scarcely exist a doubt in one's mind that the fibrillæ of a muscle cell are homologous to the spongioplasm, while the sarcoplasm is homologous to the cytolymph. The spongioplasm is not homogeneous, but consists of substances of different consistency, notable among the denser substances being the *microsomes* or protoplasmic granules. Though a homology may be traced between different features in the structure of the fibrillæ and those of the spongioplasmic threads, it is probably too early to venture a judgment on such a relation. This thing is certain: the cells which have parallel, contractile fibrillæ are lineal descendants of cells which possessed the spongioplasmic reticulum. Furthermore, the spongioplasm is active, while the cytolymph is a passive food supply, so that the analogy between fibrillæ and sarcoplasm on the one hand, and spongioplasm and cytolymph on the other, is perfect.

Let us turn briefly to a consideration of other contractile structures. The ciliated cell possesses permanent cell extensions—the *cilia*—which are in constant motion. Fig. 1508 shows the structure as it appears under favorable conditions. The fibrillæ of the cytoplasm represent the spongioplasm of the ciliated end of the cell. The cilia seem to be simple extensions of the cytoplasmic fibrillæ, interrupted at the cell border by a zone of microsomes, which, in Fig. 1509, are strongly suggestive of sarcosomes.

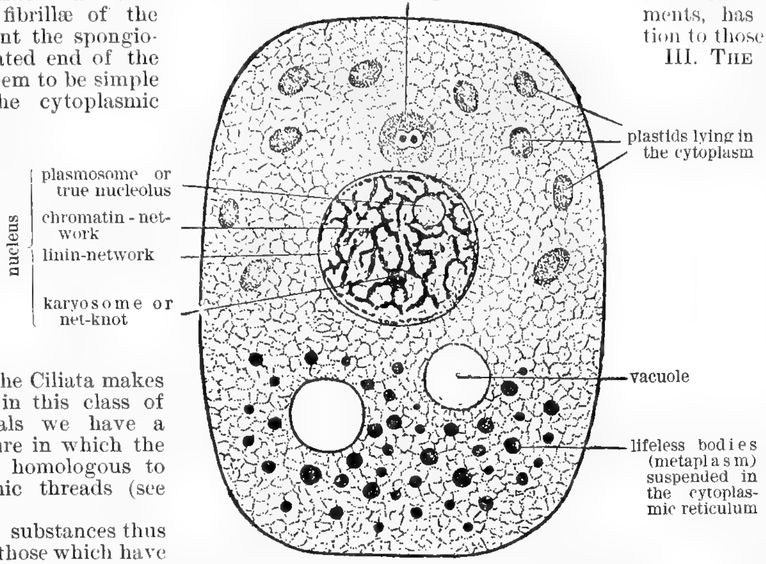
Attraction Sphere inclosing the Centrosomes.
plastids lying in the cytoplasm
nucleus
plasmosome or true nucleolus
chromatin-net-work
linin-network
karyosome or net-knot
vacuole
lifeless bodies (metaplasm) suspended in the cytoplasmic reticulum

FIG. 1507.—Diagram of a Cell. (After Wilson.) Note that this diagram contains everything which a study of actual cells, as shown above, would seem to be essential and typical in cell structure.

Biedermann's study of the property of contractility among the Ciliata makes it evident that in this class of unicellular animals we have a fibrillated structure in which the fibrillæ are also homologous to the spongioplasmic threads (see Fig. 1510).

The contractile substances thus far discussed are those which have the power of contracting in one particular direction. The Rhizopoda among one-celled animals, also the undifferentiated protoplasm of plant cells, possess the property of contractility, but the character of the movement is quite different from that of any of the animals above the Rhizopoda in that the contraction may take place in any direction whatsoever. This particular character of movement is called amœboid (see Fig. 1499). The amœba, the monera, the leucocyte, and the protoplasm of plant cells do not seem to have a protoplasm differentiated into spongioplasm and cytolymph. The protoplasm of certain, perhaps all, foraminifera is, however, thus differentiated, and it is capable of typical amœboid movements and of no other kind of movements. Fig. 1504 shows the expanded end of the pseudopod of a foraminifer. The spongioplasm is very evident in the body of the expansion, but Bütschli has not shown it in any of the extensions. The literature of the subject would not lead one to believe that the fibrillar reticulum, met with in some of the animals endowed with amœboid movements, has any causative relation to those movements.

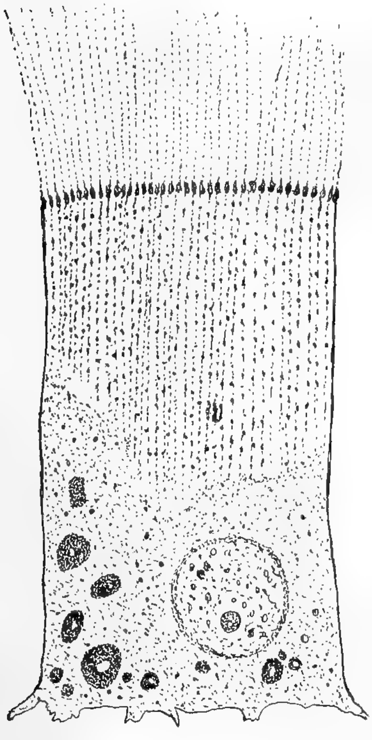

FIG. 1508.—A Ciliated Cell from the Intestinal Epithelium of Cyclas. Note the cytoplasmic fibrillæ terminating in a zone of peripheral microsomes to which the cilia are attached. (From Wilson, after Englemann.)

III. THE CHARACTER OF CONTRACTIONS.—As stated above, contractions alternate with relaxations. This condition is a physiological necessity, because contractions are the result of catabolism, while relaxations take place during anabolism, though they are not necessarily the result of anabolism.

Contractions invariably decrease the surface of a body exposed to the surrounding medium, while relaxations as invariably increase the surface exposed. When an amœba relaxes it at the same time sends out one or more extensions of the body wall, thus increasing the surface, and through the increase of surface also increasing the absorptive area, and the opportunity to come into contact with solid bodies that may serve as food. With these two advantages there always comes the disadvantage that the expanded animal is subjected to greater danger of attack by other organisms, or of injury by the environment. Contraction decreases danger, decreases supply of nutriment and knowledge of environment. This seems to be a general law applicable to higher animals and to higher orders of individuals, *i.e.*, to the municipality, the state, and the nation.

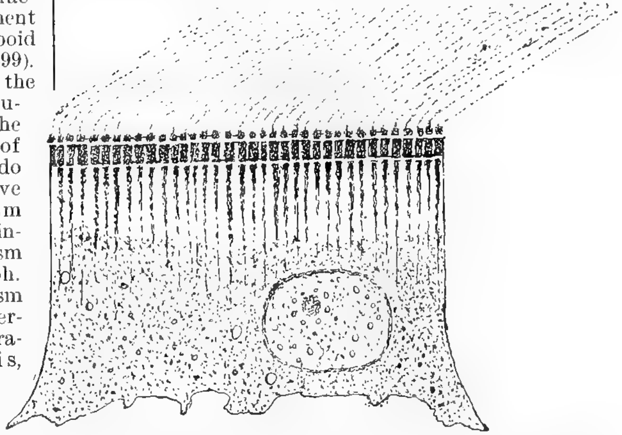

FIG. 1509.—A Ciliated Cell from the Gill of a Fresh-Water Mussel. The cilia are contracted. (From Wilson, after Englemann.)

A. The Character of Amœboid Movements.—Amœboid movements, so called because first observed in the amœba, are characteristic of the Rhizopoda in general, of leucocytes, and of some of the lower plant forms as well as of the unmodified protoplasm found in active plant cells.

The movements usually classified under this category differ slightly among themselves, and may be subdivided into the *flowing movements* which in plant cells become a distinct *circulation* of streams of protoplasm in the form of threads or strands of varying diameter from the region of the nucleus out to distant portions of the cell, usually along one side or through the middle, and returning along the opposite side or, in the latter case, along both sides. It is inconceivable that these movements could take place in protoplasm formed in part by a reticulum, much less that the reticulum could be active in causing the *flowing* and *circulation*. In this form of movement we probably have to do with the most primitive, spontaneous movements of living matter. That the terms contraction and expansion may be applied appropriately to this kind of movement is evident from the response which the protoplasm gives to any sudden, efficient stimulus it contracts into globular masses either along the course of the threads or around the nucleus (see Fig. 1511).

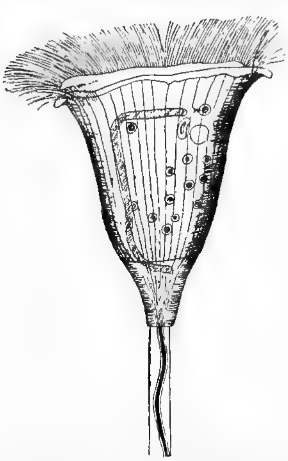

FIG. 1510.—A Vorticella (*Carchesium polypinum*). Note the converging fibrillæ developed from the exoplasm; also the muscle fibre of the pedicel.

The other form of amœboid movement shown by the higher Rhizopoda and by leucocytes is characterized by a slow pushing out of a pseudopod from any point in the surface of naked animals, but from the foramina of the foraminifera.

The mechanism of this pushing out is a matter of interest. A pseudopod cannot be thrust out as a result of simple relaxation. Relaxation is passive, and passivity never pushes. We must then have to do with some other factor than simple relaxation. There is relaxation in one dimension only and contraction in the other two. When one thrusts his tongue out of his mouth the transverse muscle fibres contract, while the longitudinal ones relax. The result is a sudden change in the dimensions of the tongue; the longitudinal axis elongating at the expense of the transverse dimensions. Something analogous to this takes place in the pseudopod of an amœba.

What we call the contraction stage is a contraction in all dimensions. This leads to the assumption of the spherical shape.

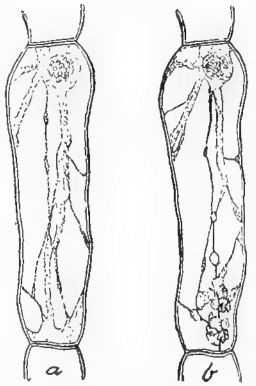

FIG. 1511.—Showing the Protoplasm of a Stamen-hair Cell of Tradescantia, expanded (*a*) and contracted (*b*).

Some, at least, of the organisms which possess the power of amœboid movement, possess also a reticulated spongioplasm (see Fig. 1504). The threads of the reticulum lie in the three dimensions and, therefore, from a mechanical standpoint may cause the movements. Inasmuch as contraction in its higher differentiation is clearly the function of the fibrillated spongioplasm or its homologue, we are justified in searching for the beginnings of this differentiation as soon as we find contractility and fibrillated spongioplasm possessed by the same organism.

B. The Character of Ciliary Movements.—In ciliary contractions we have for the first time an indubitable relation between fibrillated spongioplasm and contractility. Note that the contraction is transverse to the axis of the fibres (see Figs. 1508 and 1509). This can be accounted for only on the grounds of a contraction upon one side of the fibre or cilium, the other remaining relaxed (see Fig. 1512). (Verworn, *Allgemeine Physiologie*, p. 258).

Nobody seems to have raised the question as to how a cilium regains its erect position. Is it through a contraction of the opposite side or through elasticity?

The time and rhythm of ciliary contraction must be governed by the cells of which they are extensions, because all of the cilia of one cell contract in rhythmical unison. Upon ciliated surfaces all of the cilia act in harmony, sending a series of undulations over the surface similar to those which run over a field of wheat under the influence of the wind.

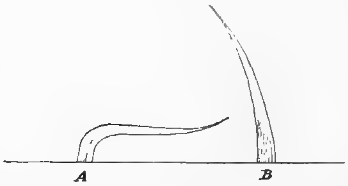

FIG. 1512.—Showing the Position and Condition of the Large and Slow-moving Cilia from a Rib of a Tunicate. *A*, Stage of relaxation; *B*, stage of contraction.

The ciliary contraction is strong and quick in one direction, while the relaxation is slow in the other; this results in a transportation, over the ciliated surface, of any bodies or matter which may be resting upon the surface, the transportation always being in the direction of the contractions.

The ciliated surfaces of the body are the respiratory tract below the larynx, the oviducts, and the vasa deferentia. The columnar epithelium of pharynx, œsophagus, and small intestine in many of the lower vertebrates is ciliated; while in man there remains of this ciliated field only a sort of vestigial, non-motile, crown of short cilia upon the columnar epithelium of the small intestine.

The function of the cilia is evidently to carry secretions along a duct or passage, or, in addition to that, to remove foreign matter, as in the case of the cilia of the respiratory tract.

Ciliary contraction may be grouped in two classes: (1) Concerted, rhythmical, undulatory movement over a ciliated area; and (2) the whip-like movements of a single large cilium called *flagellum*. A good example of flagellate ciliary movement is found in the spermatozoon. The zoöspores of the algæ usually possess one or two flagelli. The locomotion of a spermatozoon is a sculling movement.

C. The Character of Muscular Contraction.—Muscular contraction is characterized by the shortening of fibrillæ. We have already discussed at some length the minute structure of a muscle cell of some of the higher orders of animals. Biedermann ("Electro-Physiology," vol. i., pp. 3–5) traces the muscle fibrillæ phylogenetically back through the whole invertebrate division of the animal kingdom, back to the longitudinal contractile fibrillæ of the stentor and the vorticella (see Fig. 1510). In the case of the stentor the fibrils are separate throughout their course; but in the vorticella note that the separate fibrils of the exoplasm are gathered into the contractile fibre of the pedicel. The spiral course of this fibre down the inside of the elastic sheath of the pedicel causes the latter to be thrown into a cylindrical spiral when the fibre contracts (see Fig. 1513). Bied-

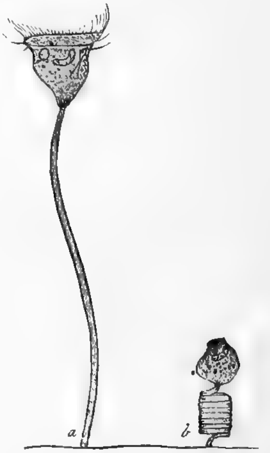

FIG. 1513.—A Vorticella Expanded (*a*) and Contracted (*b*).

ermann ("Electro-Physiology") demonstrated that a contracted vorticella returns to the expanded condition through the elasticity of the pedicel. Muscle fibrils never push; they are capable of active contraction of their longitudinal dimensions, but not of the transverse dimension to restore the original length. In this respect muscular contraction differs fundamentally from the amœboid movement. Muscle fibres may *contract and relax*, but they cannot *contract* and *expand*. During their condition of relaxation they are absolutely passive. They are, during this stage of their change, expanded; but the expansion depends upon the action of some factor outside of the fibre itself. In the case of the vorticella it depends upon the elasticity of the pedicel; in the case of the ciliary muscles of the eye it depends upon the elasticity of the tissues to which the muscles are attached; in the case of hollow viscera it depends upon intravisceral pressure; while in the case of the skeletal muscles the return to the expanded condition depends in part upon the elasticity of tissues and in part upon the active contraction of opposing sets of muscles.

Other topics on the subject of muscular contraction are discussed at length in Dr. Simon H. Gage's admirable article on *Muscle* (*q. v.*). *Winfield S. Hall.*

CONTUSIONS.—A contusion is a surgical injury—other than a fracture or a wound proper—in which the skin remains intact. If there be a solution of continuity of the skin also, the term contused wound is used.

The force producing a contusion is necessarily blunt in its nature—a blow or a fall with resulting violent compression. The lesion produced thereby is chiefly a laceration of the subcutaneous structures, varying in amount according to the degree of force applied and the resistance or state of health of the part subjected to injury.

A contusion may, of course, involve the skin alone (without breaking it), or any deeper structures, as muscle, blood-vessel, nerve, viscus, or bone. There is, in a contusion, probably always vascular rupture of some degree. The resulting extravasation has received various names, according to its apparent shape, its amount, etc. For instance, hemorrhagic spots when small and round are called *petechiæ;* when elongated, as in stripes from a whip, *vibices;* when of irregular shape, though small, *ecchymomata* or *ecchymoses*. *Hæmatomata* are localized collections of blood, of some size. The term *purpura*, while sometimes applied to small extravasations into the parenchyma of the cutis, is more generally given to a systemic disease (Werlhof's) in which such hemorrhages are a prominent symptom. *Peliosis* is used in a similar sense. *Suggillation* is sometimes considered synonymous with ecchymosis; some medico-legal writers, however, have employed the former term to indicate certain post-mortem appearances produced by the settling of the blood beneath the skin. The diagnosis between these conditions may be made by examining a section of the skin—which, if the injury was ante mortem, will be found infiltrated with blood, and firmer and thicker than natural; but if post mortem, the blood will be beneath, or upon, but not in, the cutis. Moreover, the post-mortem mottling will generally occur at the most dependent parts, and the effused blood will be found fluid.[1]

Of medico-legal interest also is hæmophilia, as those subject to this diathesis are liable to extensive extravasations resulting from slight violence; and this is also true of certain chronic cardiac, hepatic, splenic, renal, and blood diseases, in which the blood is unhealthy and the vessels of diminished resisting power. It is a fact of common observation that certain people—perhaps women more often than men—even though not subjects of serious disease, nevertheless have such delicate blood-vessels as to suffer rupture of these from even trivial causes. "Black-and-blue" spots of even extensive degree will in them consequently result from the most trifling blows or falls; and in divorce suits where "cruel and inhuman" treatment is alleged, also in suits for assault and battery, this fact should be borne in mind.

The *amount* of extravasation in any contusion will vary with the extent of vascular involvement, the degree of vascular tone, and the density of the surrounding tissues. If the bleeding take place from an artery of some size, a false aneurism, either circumscribed or diffused, may result. Or, it may be that there is no immediate escape of blood from a large vessel, and yet its walls have been so injured as finally to disintegrate, and permit a violent secondary hemorrhage beneath the skin. Or, again, an immediate true aneurism may be produced through partial rupture, usually involving the inner and middle coats.

We sometimes see cases in which the pulsation entirely ceases in the main artery of a limb beyond the point of injury. Here there has generally been rupture of, at least, the inner coat, with consequent thrombosis; or, if pulsation is only lost after some time has elapsed, this is due to obliteration from adhesive inflammation. Such instances may well be followed by dry gangrene, or moist if the accompanying vein or veins be occluded.

Diagnosis.—It is impossible to estimate the gravity of any case of contusion from mere inspection of the patient. The weight and velocity of the missile, or the distance fallen, the posture in which the injury was received, etc., should be ascertained. The surface may show no evidence of a contused and ruptured viscus within. If the vascular lesions have taken place deep in the tissues, several days may elapse before the extravasated blood reaches the skin, becoming thus of diagnostic value; and not infrequently it makes its appearance several inches distant from the seat of contusion, commonly in the direction of gravity, having dissected its way to the surface between layers of dense fascia. A late-appearing ecchymosis is thus one of the signs whereby in difficult cases a fracture may be diagnosticated.

Contusion presents a certain superficial resemblance to gangrene, but is to be differentiated by the following points: 1. The discoloration, although present in both, becomes gradually less marked and lighter colored in ecchymosis, and steadily more marked and darker in gangrene. 2. There are often numbness and diminished sensibility over a contused surface, but in gangrene the dead part is devoid of sensibility, while the dying portion adjoining is often hyperæsthetic. 3. The local temperature is frequently elevated in a contusion, whereas in gangrene it is lowered. 4. In moist gangrene, more frequently than in contusion, the epidermis becomes raised in blebs; these are less sharply defined and more easily moved about, in gangrene. 5. Emphysematous crackling may be felt in gangrene when decomposition with consequent liberation of gas has set in. 6. The foul odor of putrefaction, very faint at first, may be detected in gangrene.

The diagnosis between hæmatoma and abscess, or between it and soft malignant disease, is not always easy; but the history, the employment of the aspirating needle, and microscopic examination of the fluid withdrawn will suffice.

In the scalp a hæmatoma with hard, sharply defined border and soft centre is sometimes mistaken for depressed fracture. Here deep pressure, if need be preceded by aspiration, will show the bone to be at its proper level.

Symptoms and Course.—The immediate pain from a contusion is commonly not great. There is usually numbness of some degree, followed by heavy aching, or throbbing during the inflammatory stage, and accompanied by loss of function.

The inflammatory symptoms are simply those occurring after any traumatism, but with less tendency to become of the septic or the suppurative order than those following similar lesions exposed to the air.

Shock, in contusion, is generally proportionate to the amount of injury inflicted; but bruising of certain parts—as the breasts, testes, and large joints—induces shock in an unusual degree.

Pulping of the tissues, or injuries of the large vessels, will often be followed by gangrene.

The discoloration of the tissues and the swelling are due sometimes to the extravasation of pure blood, and sometimes to blood-tinged serum. In extravasation under a mucous membrane—as the conjunctiva—a red, aërated color is often maintained; but in other parts the well-known "black and blue" is observed in varying intensity, according to the distance from the surface and amount of blood in the effusion. Subsequently, as the blood corpuscles gradually disintegrate and become absorbed, the purplish hues fade, giving way successively to violet, olive-brown, greenish, and yellow, and the abnormal color finally disappears in from ten days to a fortnight. Several of these colors may generally be seen at once in different parts of the same contusion. When, owing to the depth at which extravasation takes place, it does not show itself for several days, it will usually appear in the form of irregular yellow spots, marbled with green and blue.[2]

The blood in a hæmatoma may remain fluid for months or years, becoming, however, gradually darker and disintegrated, and often mixed with inflammatory products. More often it is completely absorbed in a few weeks. If air be allowed to enter a hæmatoma, rapid decomposition of its contents and suppuration ensue.

The discussion of the symptoms and treatment of ruptured viscera comes more properly under other heads.

Treatment.—The indications are: 1. To limit the amount of extravasation. 2. To subdue pain, shock, and inflammatory action. 3. In severe cases to maintain vitality in the part. 4. To promote absorption of effused blood. 5. To treat complications and sequelæ.

1. Here we obtain the greatest benefit from either *heat* or *cold*, together with rest, gentle rubbing, and such a posture as will aid the return circulation. In the more superficial contusions, *heat*, as intense as can be borne, is particularly effective, and is sometimes more grateful, quieting pain better than cold. Either heat (not mere *warmth*) or cold contracts the calibre of the smaller vessels, and hence diminishes congestion and extravasation. If the cold be too intense or applied for too long a time, —as ice for several hours continuously—there will, through temporary exhaustion of the vascular muscles, be paralytic dilatation, and the congestion will no longer be diminished by this means.

The neatest and least troublesome way of applying locally either heat or cold is by the rubber coil. This I prefer to the metallic coil, because it is lighter and more easily adjusted to any part. In water-supplied rooms, the simplest method is to fasten the inlet end of the pipe over the cold or hot-water faucet. If this cannot be done, siphonage must be used.

2. To subdue pain, either heat or cold is of value, but some other analgesic agent, such as morphine, acetanilid, phenacetin, or antipyrine, by mouth, or the first and last by needle, may be required, or cocaine hypodermics may be needed.

In severe cases, systemic shock may require the use of strychnine by hypodermic and hot saline solution (normal) by the intravascular route, or the rectal; in either case at a temperature of 120 F.

The treatment of the inevitable inflammatory reaction in the irritated or partially disorganized tissues still depends mainly upon the use of cold or heat. Local blood-letting, by leeches or otherwise, may be used, but I prefer to accomplish the same result by aconite, a watery purge, and low diet.

3. Whenever a case presents itself of such severity that from disintegration and pulping of the tissues local sloughing threatens; or when coldness and a lack of pulsation beyond the injury point to occlusion of a large vessel and probable gangrene; or when local tension from extravasation or serous effusion interferes with circulation and thus indicates danger, we must not employ cold, lest we diminish still further the vitality of the part.

In the first two cases local warmth should be applied, the limb being also swathed in cotton wadding, and somewhat elevated. The best way of applying heat to tissues threatened with death is again by means of the coil. Fasten the inlet end to the hot-water faucet, and regulate the temperature of the application by varying the number of layers of cloth between coil and skin. If the whole limb is becoming cold, place hot bottles about it.

If sloughing actually takes place, poultices aid the separation of the sphacelus; and, since a poultice is simply warmth and moisture, our simplest way is to moisten (preferably with an antiseptic solution) the dressings beneath the hot coil.

In the third contingency mentioned under this heading—viz., in cases threatening gangrene from local tension,—this must be relieved by free incisions, made with antiseptic precautions; after which warmth may be used, if needed, to aid the circulation. It has been demonstrated that the greatest degree of relief to tension with the least proportion of necessary wounds, is obtained when the cuts are made to take the shape of a quincunx, or five-stroke figure.

The severest cases of contusion may call for immediate amputation, or this may be demanded by subsequent gangrene.

4. Extravasation having ceased, and inflammatory reaction subsided, moderate heat, pressure as by a Martin's rubber bandage, or gentle friction are to be employed to remove the effused blood.

According to Gross, the following application proves a satisfactory sorbefacient: Apply upon folded flannel a strong solution of hydrochlorate of ammonia, plus a small quantity of vinegar. Cover with oil silk, and renew six or eight times in twenty-four hours.

To hasten the disappearance of hæmatoma we should use elastic pressure—as by the rubber bandage—or frictions. Blisters also aid absorption, as does the use of watery purges or diuretics. If under these means there still remains a collection of fluid blood, we may, as a final resource, either aspirate, with a sterile needle, through sterilized skin, or freely and antiseptically open and drain the cavity. Should suppuration or septic change in the contents of the sac occur at any period in the history of a hæmatoma (indicated by local heat, pain and throbbing, and constitutional disturbance), free incisions and irrigation are demanded.

5. For the treatment of aneurisms, ruptured viscera, paralyses, neuralgias, hypertrophy, atrophy, etc., sometimes complicating or forming sequelæ of contusions, the reader is referred to the sections devoted to these subjects respectively.

Save for a greater degree of crushing of tissues in the former, contusions and lacerations have close resemblances. To control bleeding from the torn vessels a treatment successful in laceration would be of value in contusion. Perhaps our commonest form of laceration is a sprain—which is a tear, of varying degree, of the ligaments of a joint.

From time immemorial it has been the custom of ballet dancers, a class especially subject to sprained ankles, to immerse the injured limb at once in very hot water, meanwhile having it gently rubbed. After an hour or so, if pain permits, dancing is resumed. This plan is greatly preferable to the one until recently the custom in our profession—viz., that of simply splinting a sprained joint for a long period. Such splinting should be used only when a dislocation is otherwise to be feared, the tear of the ligaments being an extensive one.

The following is the modern treatment of a sprain: prolonged massage, in a proximal direction, while the member is subjected to moist heat; and, subsequently, the application of a moderately firm support by adhesive plaster strips. Immediate resumption of use of the joint is thereupon advised. This is often surprisingly painless, after such treatment; and the final results are not only better, but much more promptly obtained.

To some extent a contusion should be treated, if seen equally early, as is a sprain or other laceration of some subcutaneous part. In either case the prompt massage prevents the effused blood from firmly clotting where it escaped, and redistributes it. This is highly desirable, for then the torn flesh can quickly unite in natural relationship, instead of being separated by blood-clots, which would have to organize slowly. Again, the heat has the effect of contracting the blood-vessels—a thing which poulticing does, always and everywhere,—thus rendering the bleeding less, both in amount and duration.

Massage is also of extreme value later on, in promoting nutritive activity, absorption of plastic or inflammatory deposits, loosening adhesions, soothing irritated nerves, sometimes even restoring their function when it has been mechanically lost through pressure effects,—and in many ways aiding nature to overcome the results of the contusion or the laceration. Indeed, massage applied by skilled hands is doubtless our chief reliance; and in conjunction with heat (or sometimes cold) may be considered to fulfil in some measure each of the five indications mentioned under the heading of Treatment.

Robert H. M. Dawbarn.

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[1] Beck's Medical Jurisprudence.

[2] Devergie: Médecine légale, tome ii., p. 57.

CONVOLVULACEÆ.—(*The Morning-Glory Family.*) Aside from the use of the sweet potato as a food and starch-producer, this family is of medicinal interest only because of the resinous substances yielded by the tubers and tuberous roots of a number of species, and used as purgatives. The most important of these are discussed under the titles *Jalap* and *Scammony*. Others deserving of mention for the same properties are *Ipomœa pandurata* (L.) Meyer (Man-in-the-Ground, Man-Root: Wild Jalap), *I. Orizabensis* (Pel.) Ledal (Male Jalap), *I. simulans* Hanbury (Tampico Jalap), *I. Turpethem* Br. (the Turpeth of East Indian medicine) and *I. biloba* Forsk., also of India, and which contains an alkaloid. The properties are not confined to the parts named above, as the stems and seeds of some species are used similarly.

Henry H. Rusby.

CONVULSIONS.—Convulsions consist of abnormal, exaggerated muscular contractions.

Classification.—Some modern writers make the term convulsion synonymous with hyperkinesis, and thus include under it all the different clinical forms of abnormal exaggerated muscular contraction. This, is, however, an arbitrary extension of the common and accepted use of the word. The true relation of convulsions to the other hyperkineses is shown in the following table:

The hyperkineses or spasmodic disorders.
- Tremor
  - Fibrillary.
  - General.
- Contracture.
- Cramp.
- Chorea and Tic.
- Myotonia.
- Myoclonus.
- Muscular tension. (Hypertonia.)
- Convulsions.
  - Tonic spasms
  - Clonic spasms

Thus the term convulsions does not include those forms of hyperkinesis known as tremor, cramp, muscular tension, and contracture.

Convulsions, as indicated above, may be of a *clonic* character, that is, the muscles rapidly and alternately contract and relax, or they may be of a *tonic* character, that is, the affected muscles remain persistently contracted for minutes or hours. Clinically we find that these two types are often combined, as in epilepsy. Convulsions may affect the voluntary or the involuntary muscles. In the former case they have been termed *external* convulsions, in the latter *internal*.

Convulsive affections of the involuntary muscles are, from physiological necessity, of a tonic character. Something almost like a clonic convulsion, however, occurs in post-partum uterine contractions, in colicky affections of the stomach and intestines, and probably in the movements of the stomach in vomiting. The spasmodic disorders of the involuntary muscles, as in asthma, vasomotor spasms, intestinal spasms, etc., are not generally considered under the head of convulsions, and the reader is referred to these special topics. The term internal or *inward* convulsions has become popularly applied to laryngismus stridulus. Convulsions, as regards their extent, may be divided as follows:

I. General convulsions.

II. Partial convulsions: (*a*) unilateral; (*b*) those affecting certain muscles or muscular groups, known as local spasms or "tics."

The term spasms has come to be used as a very general one, identical with hyperkinesis, and it is in this general sense that I shall employ it. To avoid confusion, however, the reader should remember that older writers (Willis, Cullen, Linnæus) used the word spasm to designate the tonic form of convulsion; later writers, especially those of the French school (Savary, Georget, Brachet, Ferrand, Fauvel), define spasm as a convulsion of the muscles of organic life; while some German and English writers use the word when referring to localized convulsions.

A convulsion is only a symptom, and its presence may indicate in different cases very different pathological conditions. In many cases, however, the fact of the convulsion is about all that we know of the morbid state. In accordance with this we divide convulsions into the symptomatic, or those which are the expression of a tangible morbid change, and the idiopathic or essential. Practically we cannot perfectly carry out such a division, since such diseases as epilepsy, eclampsia, and chorea, although usually idiopathic, are sometimes caused by a morbid structural change or irritant, which is not recognized. It is customary, however, when an organic lesion is known to be at the bottom of those convulsive attacks, which are ordinarily idiopathic, to indicate the fact by some change in the terminology. Thus symptomatic epileptic convulsions are spoken of as epileptoid. Much confusion exists as to the terminology of the different pathological forms of convulsions. It is better, however, to adhere, as a fundamental distinction, to the division of convulsive disorders into only two types, viz., the idiopathic and the symptomatic, while the much-used terms sympathetic and reflex should be made subdivisions of these; for certainly the convulsions that result from a gross intestinal irritation or a pronounced blood poison are truly symptomatic. On this basis we make the following classification:

I. *Essential or Idiopathic Convulsive Disorders.*—(*a*) Those of a general character: epilepsy, hysterical and hystero-epileptic or hysteroid convulsions.

(*b*) Those of a partial character: Wry-neck, writer's cramp, spinal trepidation, salaam spasm, various peripheral nervous spasms or "tics."

II. *Symptomatic Convulsions.*—(*a*) Reflex, from wounds, injuries, inflammatory or other irritations of excito-reflex nerves. (*b*) Direct, from meningitis, tumors, hydrocephalus, focal brain lesions, brain compression, cerebral anæmia or hyperæmia, blood poisons, acute diseases.

There is such considerable confusion in the terms used by medical writers on this subject that the following further explanations are necessary. Eclampsia in infants is in many cases only symptomatic. In other instances, however, no known direct or reflex cause exists, and these form the genuine "essential" convulsions. In puerperal eclampsia, also, there is often a toxic agent at work, of which the convulsion is the clinical expression; but at other times it is a true convulsive neurosis. These true non-symptomatic cases of eclampsia are spoken of as *acute epilepsy*.

It is very evident that, as pathological knowledge advances, many of the convulsive neuroses will be relegated to the category of symptomatic diseases. This seems to be already the case for hydrophobia.

Etiology.—In studying the general etiology of convulsions I necessarily exclude tetanus and hydrophobia, which are markedly distinguished from the other forms.

Predisposing Causes.—There is a certain unstable condition of the nervous system which predisposes toward convulsions. The nerve cells are like a too inflammable tissue, which flares out at the smallest spark. The state may be spoken of as one of convulsibility. This "convulsibility" is greatest during the first two years of life, during which time eclamptic attacks are most frequent. It then falls till the fifth year, to rise again as puberty approaches. During these years, from six to sixteen, most cases of epilepsy develop. Convulsibility then gradually declines, and few cases of the convulsive neuroses arise after the age of thirty. Convulsibility is somewhat more pronounced in girls and women; and is heightened at the menstrual periods and climacteric. It is, as a rule, lessened during pregnancy, and is increased by sterility in women, and by sexual excesses or depletions in both sexes. The convulsive diathesis may be inherited, connate, or acquired. It is inherited in about one-third of the cases from ancestors of a neuropathic or tuberculous constitution. It is connate as the result of frights, injuries, or nutrition disturbances received by the pregnant mother; perhaps also as the result of intoxication of the father during the sexual act. Convulsibility is acquired, in the young, by infectious fevers, bad food and air, chronic diarrhœa, hemorrhages, and especially by rickets. As the child grows older convulsibility may occasionally be developed by bad systems of domestic and school training, and over-indulgence in emotion. At the time of puberty the abuse of the sexual function, great excess in the use of alcohol, tobacco, and absinthe, worry, fright, and mental strain, come into play. After manhood or womanhood is fully reached, it is only by the powerful and persistent action of depressant and disturbing forces that a convulsive temperament is acquired. Latent tendencies may, however, be brought out at this period.

Climate and season have a slight influence over convulsibility. Tetanus occurs oftener in cold weather; epileptic and choreic attacks occur oftener in the spring and autumn, and on wet, cloudy days, and these diseases are more frequent in temperate climates.

Race is undoubtedly a factor in predisposing to convulsions.

Exciting Causes.—These are very numerous, but vary in character chiefly with age. For details on this point the reader is referred to the special articles. Here it can only be said that in infancy the most frequent exciting causes are: pressure on the brain from meningeal, hydrocephalic, or hemorrhagic effusions, and depressed occiput; blows, acute diseases, fright, and dental or gastro-intestinal irritations. At an older age we find scrofulous tumors, uræmic poisoning, sunstroke, sexual irritations, intemperance, syphilis, the puerperal state, as active factors. Still later, cerebral tumors or hemorrhages, and injuries to the skull are potent. At all ages there is a large class of drugs which can excite convulsions; among these are lead, strychnine, thebaine, papaverine, and narcotine.

PHYSIOPATHOLOGY.—For the special pathology of the convulsive neuroses, the reader is referred to the special articles on these diseases. There are certain facts in the mechanism of their production, however, which are common to all. In a convulsive attack there are brought into functional activity—

1. A nerve centre, which is discharging its force with excessive violence.
2. Outgoing or efferent neuraxones.
3. Their peripheral end plates, and the muscle or end organ.

In reflex convulsions we must add—

4. Afferent excito-reflex neurones, carrying excitations to the irritable centre.

In order that a convulsion may occur, the nerve centre (1) must be unduly irritable or unduly stimulated, until it is made unstable; the other factors in the mechanism, (2) and (3), must be intact, and the convulsion will be favored by their being in an over-irritable state.

The agents which affect the nerve centre (1), making it over-irritable and explosive, are:

(*a*) Some inherent defect in cell nutrition, as in essential convulsions.

(*b*) Some direct chemical or mechanical irritation, as in toxic and sympathetic convulsions, and in those caused by organic disease.

(*c*) Powerful excito-reflex impulses.

Local and limited convulsive movements may be caused by irritation or interference in the regular conduction of the efferent nerves (2).

To the machinery thus described modern physiology adds another factor, viz.: 5. An inhibitory mechanism. Certain parts of the cerebral nerve centres have an inhibitory action over the function of other parts, rendering the motor cells more stable and less liable to part unduly with their energy. A convulsion may result from a too great weakening or entire loss of this inhibitory force. In the developing and undeveloped nervous system of the child, the inhibitory powers are imperfect; hence a greater convulsibility at this age.

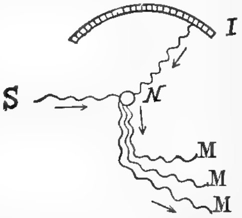

FIG. 1514.—Diagrammatic Illustration of Convulsions. I, controlling centre; N, motor nerve centre, from which neuraxones run to M, groups of muscles, and S, excito-reflex neuraxones. A convulsion may be caused by an over-irritation of N or of S, or by a depression or paralysis of I.

The more localized convulsive movements in chorea and the "tics," or local spasms, have a different origin from the foregoing. Here there is some irregular irritation of the motor cells. Thus, choreic movements are produced by irritation of some parts of the voluntary motor neurones; facial spasm generally by some irritation of the neurones of the seventh nerve. The part that the spinal cord plays in producing convulsions in man is not great and has been exaggerated. Eclampsia infantum, for example, is not the result of the defective inhibition of the brain upon the spinal cord, but rather a defective inhibition of certain higher brain centres upon lower. We see instances of true spinal convulsion (spinal epilepsy, spinal trepidation) in chronic diseases of the spinal cord implicating the pyramidal tracts, at the beginning of the third stage of anæsthesia, and in infants, children, or sensitive adults just as they are dropping off to sleep.

SYMPTOMS.—The general convulsions of eclampsia, epilepsy, hysteria, and hystero-epilepsy have common features. There are often prodromal symptoms, indicating an over-irritable or depressed state of the nervous system. The attacks themselves come on suddenly, sometimes with an immediate prodromal symptom or aura. The muscular movements are irregular and incoordinated, except in some phases of hysterical and hystero-epileptic convulsions. Consciousness is generally abolished, as are also sensibility and the reflexes. Very marked secretory disturbances occur. The vasomotor system is greatly involved, especially that part which controls the blood supply of the brain. The face and probably parts of the brain are at first blanched, but the anæmia is soon followed by pronounced passive hyperæmia. In eclampsia infantum, however, the first sign of the impending attack is sometimes a cerebral hyperæmia, and the convulsion may be arrested by pressure on the carotids. Respiration is disturbed, and the heart beats at first more slowly, then more rapidly than normal.

DIAGNOSIS.—The diagnosis of a convulsion is easy. One has only to differentiate it from malingering. The state of the pupils, of the reflexes, and of the sensibility, and the want of art upon the part of the malingerer, are generally quite sufficient to clear up the case. As to the form of convulsion, the difficulty in diagnosis may lie first in determining whether an attack is one of eclampsia or of epilepsy. Eclampsia occurs oftenest before the age of two years; the attacks are less sudden, more irregular, more prolonged, and less severe than in epilepsy. Usually there is no frothing at the mouth. After the age of two, idiopathic convulsions are most probably epileptic. It is important to distinguish between hysterical, hysteroid, and epileptic convulsions. All that I can say here, however, is that in the two former types the movements are more co-ordinated, consciousness is not entirely lost, sensibility may be present, and hallucinations may develop.

It is very important to determine whether the convulsion is idiopathic, or symptomatic of some general disease, reflex irritation, or organic central affection (see *Chorea*, *Eclampsia*, *Epilepsy*, *Hysteria*).

In some forms of convulsions it is necessary to make an anatomical diagnosis. If the symptoms are in the main bilateral, the cause is to be referred provisionally to the medulla; if they are unilateral, or involve special muscular groups, the convulsion is presumably symptomatic of a lesion in some part of the intracranial pyramidal tract, basal ganglia, or motor cerebral cortex of the opposite side.

There is a certain probability that convulsions in infancy are essential; in childhood are meningitic, febrile, or epileptic; in maturity and old age are symptomatic of syphilis or structural lesions; in women are hysterical.

Prognosis.—As regards the attacks, the danger to life is greatest in infantile and puerperal eclampsia; next in the degree of danger comes a special form of convulsion, viz., laryngismus stridulus; then follow choreic and epileptoid convulsions, epilepsy, hystero-epilepsy, and hysterical convulsions. As regards recurrence and final cure no general comparisons can be profitably made.

Treatment.—The general principles governing the therapeutics of convulsions are nearly the same for all. For the attacks, removal of sources of irritation, the use of chloroform, ether, morphine, amyl, nauseants, bromides, and chloral are indicated. For the disease, removal of all direct or reflex irritants and a treatment calculated to lessen the irritability and increase the tone and nutrition of the nervous system are indicated.

In the convulsions of children the common and effective practice is to place the child in a warm bath. In convulsions of adults, when drugs cannot be given by the mouth, enemas of thirty to forty grains of chloralamid are efficacious. In hysterical convulsions hypodermic injections of apomorphia, gr. ⅛, or morphia, gr. ¼, may be given. *Charles L. Dana.*

COOPER'S WELL.—Hinds County, Mississippi.

Location.—Twelve miles east of Jackson (by stage) and 4 miles from Raymond.

This is one of the famous old-time resorts of Mississippi, and the waters of the well have attracted more attention in days gone by than any others in the State. The well is one hundred and seven feet deep and its flow very abundant (Walton). The following analysis was made by Prof. J. Lawrence Smith:

One United States Gallon Contains:

Solids.	Grains.
Potassium sulphate	0.61
Calcium sulphate	32.13
Sodium sulphate	11.71
Aluminum sulphate	6.12
Magnesium sulphate	23.28
Sodium chloride	8.36
Calcium chloride	4.32
Magnesium chloride	3.48
Iron peroxide	3.36
Calcium crenate	0.31
Silicon crenate (?)	1.80
Total	95.48

This is a very valuable mild chalybeate water, containing a certain proportion of purgative salts and bearing considerable resemblance to the waters of Bocklet, near Kissingen, in Bavaria. This combination adapts the waters to numerous conditions in which anæmia is associated with constipation or abdominal plethora. Its effects are found to be very satisfactory in dropsy and in chlorosis. In chronic diarrhœa it has long held a high repute. The water acts as a diuretic or aperient according to the quantity used and the mode of drinking. *James K. Crook.*

COPAIBA.—Balsam of Copaiba. "The oleo-resin of *Copaiba Langsdorffii* (Desf.) O. Kuntze, and of other species of Copaiba (fam. *Leguminosæ*)" (U. S. P.). Of the sixteen gigantic trees of this genus, twelve are tropical American, and of these seven are known to contribute to the copaiba of the market, as follows:

C. Langsdorffii (Desf.) Kuntze, *C. confertiflora* (Benth.) Kuntze, *C. coriacea* (Mart.) Kuntze, *C. oblongifolia* (Mart.) Kuntze, all of Brazil, *C. officinalis* Jacq. in the Orinoco valley, and *C. Guyanensis* (Desf.) Kuntze and *C. multijuga* (Hayne) Kuntze of the Amazonian region.

Several species furnish ornamental woods for cabinet work, the so-called "amaranth," or purple wood, being one of them. The timber is also highly prized for boat and wheel making in tropical America, and the seeds are used like vegetable ivory, for small objects.

Collection.—The stems of the copaiba trees contain numerous oil canals and cavities, in which the liquid is accumulated as turpentine is in those of the pine trees. But the copaiba canals are much larger, sometimes even exceeding an inch in diameter, and they traverse the whole length of the stem. Into these the copaiba is freely secreted. Indeed, the pressure of it in them is said to be sometimes so great as to split the trunk itself and to find spontaneous exit, as is also true of one or two other oleiferous trees. As may be supposed, the process of collection is simple enough: a deep gash cut into the trunk, reaching the heart-wood, hollowed and slanting below so as to collect the flow, provided with an improvised spout made from the bark itself, or with a leaf, and a receptacle to contain the oil as it flows in a steady stream, are the essentials. It is carried on mostly by the Indians. The yield is enormous, and may reach from ten to fifteen gallons from a single tree.

The principal amount, as well as the finest quality of this drug, is exported from Pará, in Brazil, generally in barrels. Other Brazilian ports, as well as Angostura, Cartagena, Maracaibo, and Trinidad, also export that which is collected in their respective neighborhoods. The products of different countries vary a little in their sensible qualities, and are, in trade, designated by their geographical names; that of Pará is thinner and paler, and rotates the polarized ray to the left; those of Venezuela and Trinidad are thicker and brownish, and rotate to the right. Some species are, moreover, opalescent, others perfectly clear. There is the greatest difference in their medical efficiency.

Copaiba has been known in Europe something more than two hundred and fifty years. Its usefulness was learned from the aborigines of Brazil, among whom it was highly esteemed.

Description.—The consistence and color of this substance, although probably depending in part upon its natural amount of oil, vary also with age and exposure, becoming thicker and darker as the oil evaporates. Fine fresh Pará copaiba is a clear liquid, about as thick as Canada turpentine, and of about the same color. It is often darker, however, and may have a deep golden yellow, or even a sherry tint. Copaiba has a peculiar, aromatic, somewhat terebinthinous odor, and a persistent, bitter, biting, disagreeable taste. Its specific gravity varies from 0.916 to 0.993, and it is soluble in absolute alcohol and in four times its bulk of petroleum spirits. Some varieties, as noted above, are not quite clear, and are sometimes fluorescent. In evaporating a small quantity, there should be no odor of turpentine, and the residue, when cold, should be hard and easily rubbed to powder. It should not boil under 482° F. and should rotate to the left 28° to 34°. Four drops, carefully added to a mixture of half an ounce of glacial acetic acid with four drops of nitric acid, should not afford a reddish or purple color.

Composition.—It contains from forty to sixty, or even eighty per cent., according to its fluidity, of an *essential oil* of the composition $C_{10}H_{16}$, or $C_{20}H_{32}$, of high boiling point, and the odor and taste of the drug itself. A good Surinam article contains seventy-eight per cent. This is also official (*Oleum Copaibæ*, U. S. P.). The crude *resins* left behind in the distillation are also official, under the name Resin of Copaiba (*Resina Copaibæ*, U. S. P.). It is a brownish-yellow, brittle substance, with the appearance of common resin, but having the odor and taste of the oleo-resin. The "resin" of Brazilian (Pará) copaiba is really a natural mixture of at least two substances—an *amorphous indifferent resin*, probably itself compound, and the crystallizable *copaivic acid*, obtained in large, white, nearly odorless prisms. The latter is insoluble in water, and sparingly so in ether, but strong alcohol and the fats dissolve it freely. *Oxycopaivic acid* is an analogous substance, sometimes also met with. "Maracaibo copaiba," that is, the product from the northern coast, yields in a similar way, together with its amorphous resins, crystalline *metacopaivic acid* instead of *copaivic acid*, which dissolves freely in ether as well as in alcohol.

Copaiba is apt to be adulterated; one of the commonest additions is castor or some other fixed oil; Gurjun balsam, oil of turpentine, and other volatile oils are also sometimes added.

Action and Use.—Large doses of copaiba occasion vomiting, purging, and colic, symptoms due to its locally irritant action upon the alimentary canal; they also may cause some difficulty in micturition, with burning pain in the urethra, or even strangury, but the latter is rare. Copaiba is mostly eliminated with the urine, which it increases and changes in odor. According to Brunton, "it forms a conjugate glycuronic acid in the system, and is eliminated in the urine, which with nitric acid gives a precipitate of copaibic acid, easily mistaken for albumen, but distinguished by disappearing on the application of heat. The conjugate acid renders the urine antiseptic, as it is secreted by the kidneys, so that it does not readily decompose, and bacteria either do not appear in it at all or only in very small numbers, even after the surface has become covered with mould." This, if true, may explain at least a part of its usefulness in the urethral and vesical catarrhs, for which it is so much employed. Its elimination products, if sufficiently diluted, appear also to be soothing to the lining membrane of the urinary tract. A portion of the copaiba taken makes its exit from the lungs, as shown by the breath. The principal call for this medicine is in catarrhs of the genito-urinary system, especially of the urethra and bladder. In gonorrhœa and gleet, its employment at one stage or another is almost universal. In chronic vesical catarrh it is also sometimes useful, and more rarely so in chronic bronchitis. Its value in chronic diarrhœa and dysentery, and as a diuretic in cardiac dropsy, is more doubtful. In the acute stage of the above affections, it is not to be advised. An erythematous eruption occasionally appears during the use of the medicine; this, however, departs as soon as the drug is omitted.

Administration.—The oleo-resin itself is generally given. From ♏ x to xx. (a gram = ♏ xv.), three or four times a day, is the usual dose. Dropped upon a lump of sugar, it can be quickly chewed and swallowed, or an emulsion can be made of it with flavored syrup of acacia or yolk of egg. In either case its taste is very disagreeable and persistent. It may be solidified by adding six per cent. of magnesia (Massa Copaibæ, U. S. P.), and made into pills, but the value of this preparation is doubtful. A sort of soap may be made by adding enough *liquor potassæ* to cause it to mix with water. More than by all these methods, it is at present given in gelatin capsules, which are prepared on an extensive scale by numerous manufacturers; they contain from five to ten drops each, and two or three can be taken at a dose, two or three times a day. They are perfectly free from its taste, but the odor will appear in the breath, after an hour or so, as well as when it is taken undisguised. The oil and the resin may be given in similar doses and ways. The action of the oil is not very different from that of the undivided oleo resin.

Allied Drugs.—Copaiba differs in degree more than in kind from the numerous class of essential oils and resins, being milder than some (turpentine), and more stimulating than others (the carminatives). Cubebs, buchu, and oil of sandalwood have similar action and are employed for similar conditions, but none of them is equal to it. Gurjun balsam has also similar qualities, and has been substituted for copaiba. Uva ursi, and the arbutin and benzoic acid class of remedies may be compared with it, and so may also, in a certain sense, as used for the same disease (gonorrhœa), the vegetable and mineral astringents, hydrastis, and several inert powders used in injections; but the action and characters of these substances are not at all like those of copaiba.

W. P. Bolles.

COPAL.—(Including *Animi* and *Kauri*.)—This name is applied to a number of resins of similar nature, but of widely different origin, both botanically and geographically. As the article is only of mechanical interest, and the different varieties are so similar, they need not be discussed here. It is mostly dug from the ground in a fossil condition, though the trees yielding at least most of the varieties are still in existence. Copal is very hard, of glassy or splintery fracture, of various shades, from light yellow through reddish orange to dark reddish brown, and usually translucent, though sometimes milky or smoky. It may be smooth or dusty or (the best variety of animi) very warty. It occurs in pieces varying from the size of a marble to that of a mass weighing many, in one case several hundred, pounds. It is without odor and taste and the ordinary solvents of resin dissolve it only with difficulty. Its uses are purely for varnish and other mechanical coatings.

Henry H. Rusby.

COPPER.—General Medicinal Properties of Compounds of Copper.—As usual in the case of compounds of the heavy metals, impregnation of the blood with a copper compound tends to affect nutrition. In medicinal doses too small to produce any obvious derangement, the influence tends to the abatement of spasmodic nervous disorders, but not to a sufficient degree to enable copper to compete with zinc and other remedies as a practical antispasmodic. In excess of medicinal dosage copper salts are readily poisonous. Locally, soluble copper salts, such as are alone used in medicine, are powerful irritant astringents. Applied in concentrated form to a moist surface they combine with the albuminous elements of the part, forming a thin, practically invisible slough, and at the same time constringe and irritate. So far as the caustic effect is concerned, it is so superficial as to be of little moment, so that practically the action is simply conjoint astringency and irritation. Such action, however, may determine absorption of easily absorbable tissue, such as granulations, or the healing of indolent ulcers, or the abatement of a catarrhal process. Taken internally, in any beyond quite small dosage, the irritant action of soluble copper salts declares itself by producing at once full and free vomiting. Such vomiting is attended with little nausea or depression, and the emetic dose is itself discharged with the ejecta. Copper salts thus become available medicinally as emetics, and because of their power and promptness of action are peculiarly appropriate for the dislodgment of poisons by vomiting. In considerable single overdose copper salts are irritant poisons.

The therapeutics of copper compounds are comprised in the applications set forth above—locally for an astringent irritant operation, internally to provoke vomiting, or in smaller dosage for an astringent effect in diarrhœas. For the latter purpose, however, other astringents more agreeable than copper compounds are commonly preferred.

A single compound, only, of copper is official in the United States Pharmacopœia, namely, the *sulphate* (cupric sulphate, $CuSO_4,5H_2O$). The salt is entitled *Cupri Sulphas*, Copper Sulphate, and is the one so well known by the common name of *blue vitriol* or *bluestone*. It occurs in "large, transparent, deep blue, triclinic crystals, odorless, of a nauseous, metallic taste; slowly efflorescent in dry air. Soluble, at 15° C. (59° F.), in about 2.6 parts of water, and in 0.5 part of boiling water; almost insoluble in alcohol" (U. S. P.). The salt effloresces slowly on exposure, or on moderate heating, to an opaque, pale blue powder. Cupric sulphate may be used locally in substance, a smooth crystal, with its edges rounded by a file, being selected, or cylindrical or conical pencils may be made by fusing one part of alum with two of the copper salt and shaping in suitable moulds. Lotions are made by aqueous solution, the strength ranging from one-half to two per cent. As an internal astringent the dose is about 0.015 gm. (gr. $\frac{1}{4}$); as an emetic from 0.12 to 0.30 gm. (gr. ij.-v.) or more if the stomach be insensitive from narcotic poisoning. But if a full dose is given, and fails to vomit, it must be removed by the stomach pump lest undue gastric irritation result. The salt is best given in powder, mixed with powdered sugar.

Edward Curtis.

COPPER, POISONING BY.—Copper is poisonous to man and the lower animals in any of the forms in which it may be brought into the circulation, and its toxicology is of special interest because of its widespread occurrence in nature and its extensive use in the arts. The commercial compounds of chief medico-legal interest are the sulphate and the acetates. The crystallized sulphate, $CuSO_4, 5H_2O$, also known as blue vitriol or bluestone, is extensively used in calico printing, in electro-metallurgy, as a fungicide in agriculture, and to some extent in medicine. There are several acetates used in dyeing and calico printing and as pigments. The several varieties of verdigris are basic acetates of different chemical composition. Other important compounds are the nitrate, chloride, and the arsenical pigments, as Scheele's green and Paris green. Metallic copper as such, and in the form of its numerous alloys, is extensively used in manufacturing industries, and hence many persons are exposed to its influence.

Notwithstanding the toxic character of copper compounds and their ready accessibility, poisoning in man is not common in this country and fatal poisoning may be said to be rare. Copper salts have been used for criminal poisoning, but more frequently for suicide. Usually the poisoning has been accidental.

To understand the present state of the question of poisoning by copper, it is necessary to distinguish clearly between the effects of the corrosive local action in the alimentary canal and the general systemic poisoning due to the metal after its entrance into the circulation. Within a few years the problems have been especially studied from the experimental side (Harnack, Lehmann, Tschirch, Filehne, Brandl).

Physiological Action.—A soluble salt of copper has little or no effect on the sound skin, but acts as a mild caustic to surfaces denuded of cuticle, and on the mucous membranes as an astringent, irritant, or corrosive according to the form in which it is applied. Administered internally it acts as a prompt emetic, but if not thus expelled it produces a more or less severe gastro-enteritis with the local and general symptoms which accompany this condition. Relatively small amounts are absorbed from the stomach and intestines, but enough may be taken into the circulation to produce a general intoxication, especially with animals that do not vomit, and in the case of very large doses. In the latter case it is believed that the local destruction of the integrity of the epithelium favors the absorption. Systemic poisoning has, however, been especially studied by the subcutaneous or intravenous injection of organic salts such as the copper sodium tartrate (Harnack, Filehne). The symptoms observed after these injections have been loss of appetite, trembling, weakness with loss of co-ordination of muscular movements progressing to more or less complete paralysis, slowing of the heart action and respiration, with death due to cardiac or respiratory failure. Vomiting may occur, and in continued cases diarrhœa and other symptoms of intestinal disturbance are usually present. Later symptoms of special interest are extravasations of blood in various places, due to destruction of blood corpuscles; jaundice, due to fatty degeneration in the liver; hæmaturia, due to congestion and later fatty changes in the cortex of the kidneys. The unabsorbed copper is chiefly converted into the sulphide and is found in the fæces. That which is absorbed is eliminated in part in the urine, but chiefly through the bile. Ellenberger and Hofmeister found from six to ten times as much copper in the bile as in the urine. They detected it in the urine within thirty-six hours after the first dose, but were unable to find it after nine days, while it was detected in the bile as late as forty-one days.

Acute Poisoning.—The ingestion by man of a large dose of a salt of copper is usually promptly followed by the symptoms of an irritant poison. The symptoms may begin within a few minutes, ten to twenty, or they may be delayed, from two to three hours. They begin with nausea followed by prompt vomiting of green or bluish material, and by a metallic taste, thirst, burning in the stomach, abdominal tenderness increased on pressure. There is usually purging, the passages being abundant and frequently bloody. Owing to the prompt emetic action the poison may be very completely removed and the case tend rapidly to recovery; indeed, this is the usual result.

In some cases death has followed a single large dose. The symptoms in these cases have been similar to those described, but more severe, and accompanied by intense headache, cramps in the limbs, great prostration, cold extremities, small rapid pulse, and other symptoms which accompany the collapse caused by extensive gastro-intestinal inflammation. Death may result in from four to twelve hours, but generally only after a longer period; two, four, or eight days, or even longer. After the first few hours there are added to the symptoms due to the local action of the poison, those caused by the action of that which is absorbed, on the kidneys, liver, and other organs. Thus the urine is more or less suppressed, is albuminous, and contains casts and blood. Jaundice may be present, but is usually a late symptom. If a case of this sort progresses to recovery the progress is slow. Chronic gastro-enteritis is a likely sequel.

Fatal Amount.—Metallic copper has been frequently ingested in the form of coins, etc., with no evil effect, but there are well-authenticated cases in which copper in the metallic form has produced the symptoms of copper poisoning. Experiment has also shown the toxic character of the metal. When fed to dogs in their food, copper dust produces vomiting in even small doses, but there is little evidence of systemic action even after long periods of feeding small doses (Filehne).

The lethal quantity of a copper salt for man is stated very differently by the authorities: Husemann, 25–30 gm.; Lewin, 15–20 gm. of the acetate, 10 gm. of the sulphate; Kobert, 10 gm.; Tardieu, 2–3 gm.; Seidel, 1 gm. These figures obviously refer to different modes of action, for a consideration of the reported cases makes it probable that only a large dose, 10–20 gm., of such a salt as the sulphate, would produce death by its direct local action.

That relatively small doses may prove fatal when absorbed is evident from the results of animal experiments. Rabbits are killed in twenty-four to thirty hours by the subcutaneous injection of doses of copper sodium tartrate, equivalent to 0.015 gm. of CuO per kilogram (Filehne). That the minimum fatal dose for man if administered in this way would likewise be small cannot be doubted, and therefore the minimum dose by the stomach would be small if administered under favorable conditions for absorption, though doubtless modified by the protective action of the liver. That the conditions for absorption from the stomach are unfavorable is shown by the usual type of the cases which occur, and also by the results of the administration of copper compounds for therapeutic purposes. Thus Husemann instances a case in which 17 gm. of sulphate were taken in six days with no toxic effect. The conditions effecting absorption must therefore control the amount which would be lethal in any given case.

Post-Mortem Appearances.—The marks of inflammation throughout the alimentary tract are the most common observation. These may consist of injections, ecchymoses, ulceration, or even gangrene and perforation.

The mucous membrane may have a greenish color due to the presence of some copper compound, which is easily distinguished from bile stains by the blue reaction with ammonia. Contrary to the usual condition, all signs of inflammatory changes may be absent. In late deaths the tissues may be bile-stained and the liver and kidneys swollen and fatty. The heart muscle has also been found fatty. These degeneration changes show clearly that in man copper may be absorbed from the alimentary tract in not inconsiderable amounts. Absorbed copper is found chiefly in the liver, but also in the kidneys and other organs, in the muscles and in the blood, where it is said it exists in the corpuscle in combination with hæmoglobin (Filehne). It may be easily isolated by the Fresenius method commonly used in toxicological examinations of tissues.

Treatment.—As antidotes milk and egg albumin may be used because of the difficultly soluble compounds which copper forms with proteids. Magnesia is a suitable addition as an antacid. Reduced iron has been recommended with the view of precipitating metallic copper. Potassium ferrocyanide produces an insoluble copper ferrocyanide and is the best chemical antidote, but is not without danger in large doses because of its tendency to form prussic acid. The stomach should be thoroughly washed out even if there has been free vomiting. The subsequent treatment should be directed with reference to the local lesions, the collapse or prostration, and to the condition of the kidneys.

Chronic Poisoning.—Contrary to the earlier teachings, recent observations tend to the view that there is no chronic copper poisoning comparable with that by lead. According to this view the long-continued ingestion of minute doses of copper by the stomach, and the exposure to absorption in handling and working the metal, are not capable of producing the systemic poisoning. This view is based on the negative results obtained in feeding-experiments with man and the lower animals, and in the therapeutic use of copper salts. There can be no doubt that the danger of poisoning with copper has been exaggerated, and that it is much less poisonous than lead. In view, however, of the well-known effect of the injection of copper salts subcutaneously it would appear that the question of a chronic systemic intoxication is largely a question of absorption, and that it would be unsafe to conclude that absorption may not occur from small doses to a sufficient extent to be toxic. Cases of poisoning have been described among workers in copper and brass that appear to admit of no other explanation, but those that can be classed as chronic are certainly rare.

The Use of Copper Utensils in Cooking Food.—Cooking-vessels of copper and copper alloys, especially of brass, have been used very extensively. Repeated experiments have shown that foods may be impregnated with copper on long standing in such vessels, and this is especially so of foods containing vegetable or fatty acids. Thus Mair found 0.024 gm. per cubic liter in rice soup which had stood twenty-four hours in a brass vessel. A liter of vinegar containing an acidity of three and a half per cent., on being boiled in a brass vessel and then allowed to stand has taken up 0.183 gm. of copper in twenty-four hours and 0.365 gm. in two days. Direct experiments tend to the conclusion that food cooked in the usual way in bright copper or brass vessels, but not allowed to stand in them, does not absorb a sufficient amount of copper to produce symptoms of poisoning. It seems impossible that enough could be present in food which would be eaten at one time to produce serious acute poisoning as has been frequently supposed, especially as the presence of as much as half a gram of dissolved copper in a kilogram of liquid food would produce a marked metallic taste.

The Use of Copper in Preserved Foods.—Copper salts are used in the preparation of canned vegetables such as peas and beans, and of pickles, in order to impart a desired green color. This is accomplished by heating in a very dilute solution of copper sulphate. The vegetables thus become impregnated with copper, which probably exists in combination with the proteids in part, and partly with the chlorophyll. The presence of 0.020–0.030 gm. of copper per kilogram is all that is needed to accomplish the desired result, but ten times these amounts have been found in canned peas. The copper fails to give its ordinary reactions in the compounds in which it exists in these preparations, and it is extracted only in part by acid of the strength of the gastric juice. According to Tschirch and Brandl the metal in these forms is but slightly toxic. From experiments with copper proteid Filehne concluded that an amount equivalent to 0.500 gm. of copper per day would produce no notable result in an adult. Copper sulphate has been used in bread-making to improve the appearance of the product made from inferior grades of flour. Only small quantities can be used, because the yeast is very sensitive to the toxic action of copper salts; 4–16 mgm. per kilogram have been found.

The Occurrence of Copper in Plants and Animals.—Plants exhibit great variation in their susceptibility to the toxic action of copper salts; some, like the fungi, are very readily destroyed by it, so that copper salts are widely used as fungicides in agriculture. The higher plants, however, are less easily affected by it as applied externally or as existing in the soil in which they grow. Indeed, some kinds may absorb notable quantities from the soil, and it therefore happens that many articles of vegetable food contain copper. Thus Lehmann found vegetables as sold in the Würzburg market to contain the following amounts of copper per kilogram of dry substance: lettuce, 0.003–0.010 gm.; gurkins, 0.030 gm.; beans, 0.018–0.020. In vegetables grown in a soil very rich in copper he found larger quantities; *i.e.*, 0.080–0.560 gm. copper per kilogram of dried substance. Animals feeding on vegetables containing copper naturally absorb some of the metal and it is found in variable small amounts in the tissues. Thus there have been found in fresh yolks of eggs 0.0005–0.002 gm. of copper; in muscle of the ox and sheep about 0.001 gm.; in kidneys 0.002–0.008 gm., and in liver 0.009–0.030 gm., per kilogram. Carnivorous animals contain less. In man it is very commonly found in the liver to the extent of a few milligrams. So constantly is copper found in man that it has been spoken of as normal copper by some writers. It performs no known function, and is to be regarded not as normal but as accidental, though nearly constantly present. The amount present depends on the character of food, and possibly on the occupation of the person.

Herbert E. Smith.

COPULATION, or sexual contact, is essential to the process of reproduction in all the more highly organized species of the animal kingdom. An analogous step in the process has in fact been traced upward from a comparatively early phase of plant life, for sexual reproduction is the rule among all but the lowest orders of plants. Actual contact is, however, exceptional. In most of the flowering plants fertilization depends upon an indirect transfer of pollen through the medium of air or water or by the agency of insects. Yet, on the other hand, in some of the lowest forms of cryptogams, flowerless plants, more or less intimate contact or union of two individuals is necessary, and in some of the higher species of thallogens the union closely resembles that of the animal kingdom.

In the lower forms of animal life much difference is observed both in the manner and in the duration of the connection, and in not a few instances peculiar changes occur in some of the organs or parts of one or both sexes for the purpose of copulation. Earthworms, for example, become firmly united, two segments of each having previously undergone necessary changes. In some orders of the crustacea the male organ resembles a rudimentary foot which is thrust into the vulva. The true character of this appendage is demonstrated by the presence in it of a vas deferens. A similar transformation of a member is seen among the cephalopods; for in some species of the cuttlefish the male and female become firmly attached to each other, mouth to mouth, with the suckers of the arms in apposition. While thus embracing, one of the arms is detached by the male and it is deposited within the mantle of the female. The arm thus detached has been previously "hectocotylized," that is, a sac filled with spermatophores has been formed upon it. These are discharged within the mantle and are carried to the ova through a tube which perforates the terminal filament.

Among insects the alteration of limbs and abdominal segments is sometimes quite remarkable. Reproduction is invariably a result of sexual union except in a few instances of hermaphroditism. Among the hymenoptera (bees, ants, flies, etc.) the connection lasts from a few seconds to several hours. The male bee is sometimes so injured by prolonged contact that his death immediately follows the separation. The fantastic position of the dragon-fly during copulation is due to the peculiar position of the organs in the two sexes. That of the male is situated in a slit on the under surface of the second abdominal segment, that of the female on the under surface of the eighth segment. In spiders we find conditions which more resemble those seen in some of the cephalopods than in the insects, for the spermatic fluid is deposited in a receptacle in the chela, or claw, and is then thrust into the cloaca. The first appearance of a true penis is found among the amphibia.

Among the vertebrates also there is a gradual transition from a very simple to a more complicated method of copulation as we ascend from the lower to the higher orders. In the former the organs are rudimentary, recalling the altered segments of the earthworm. Some species of fish do not copulate; fertilization of the eggs occurs after they are in the spawn. In some there is a momentary contact, while others are said to remain united until they are accidentally separated. In some elasmobranchs peculiar "claspers" at the posterior extremity of the male, supposed to be rudiments of a third pair of limbs and intended primarily for maintaining contact, seem to be partially introduced. Among birds there seems to be no deviation from the copulative method of fertilization, but the process varies from a momentary contact in the smaller species to one as complicated as that of the higher quadrupeds in some of the larger, notably in the ostrich.

Considered merely in its relation to procreation, copulation, in the human being, consists essentially in nothing more than the deposit of seminal fluid within the vagina, even in the vestibulum, for it is well known that conception may occur without actual penetration. This would limit the act in the male to the period of life between puberty and an indefinite time of old age, and in the female to the period of ovulation. A man may procreate so long as his seminal fluid contains living spermatozoa, although he may be able to perform the sexual act but imperfectly; but in the female the possibility of impregnation ceases with the completion of the menopause. But no such limit can be drawn. The ability of the male to copulate, as the term is ordinarily understood, depending almost wholly upon erection of the penis, begins in early childhood and lasts until the development of senility. There is practically no age limit to its possibility in the female after childhood. The part taken by the male and the female will be more conveniently considered separately.

The Male.—To place a physiological limit upon the frequency of copulation in the male is hardly possible, for in the human being there is no such natural limitation as we see in most of the lower animals, and under the many exciting influences of civilization, sexual desire is exceedingly variable. Neither is desire a proper criterion of the normal requirements, for in some men it is aroused not merely by the accumulation of seminal fluid after prolonged continence, which seems to be the normal stimulus, but by the perception of an attractive female through any of the senses or even by the imagination alone. Although we admit that the testicular secretion is constant and that absolute continence is not strictly physiological, still the normal limit of indulgence may undoubtedly be exceeded. A man may indulge so frequently that, although he experiences the usual excitement and an apparently normal orgasm, the ejaculated fluid becomes devoid of fecundating property. Such frequency is clearly abnormal. It is generally followed by undue depression if not by more lasting evil effects. On the other hand, it must be admitted that the evil effects of continence are seldom of consequence in the absence of unnatural excitement and uninfluenced by previous immoral practices. The emergency rarely arises in which the physician can recommend illicit intercourse without compromising himself professionally as well as morally. Within the bounds of legitimacy there can be no question that the practice should not exceed the gratification of natural desire, a desire which varies, however, with the physical vigor and health of the individual, his mode of life and climatic influences, and usually diminishes to some extent with advancing age.

The anatomy of the male organs is appropriately considered in another volume of this work, and it will be necessary therefore to describe only briefly the mechanism of erection. It has been shown that the erection and rigidity of the penis depend upon a temporary increase in the size of the arterioles which supply blood to the erectile tissue of the spongy and cavernous portions, more than upon constriction of the veins which carry away the blood; but such constriction probably increases the turgescence, especially for a short time during the period of greatest excitement. The nervous control of these vessels comes from the sacral plexus and is practically the same as that of the integument and muscles of this entire region.

The sensation experienced in coitus depends for the most part upon the sensitiveness of the glans, the acuteness of which increases with the rigidity; it is aided by nervous excitement and by friction within the vagina until the orgasm occurs. As this stage is reached a different sensation is developed, probably by increased peristaltic action of the vesiculæ seminales and by the rhythmical contraction of the bulbo-cavernous muscle, which culminates in the forcible discharge of semen. Following this the venereal excitement quickly gives place to a variable degree of lassitude and the sensitiveness of the organ to a feeling resembling fatigue.

The Female.—The part of the female is passive, at least to a much greater degree than is that of the male. To some women there is no feeling of pleasure, much less an orgasm comparable to that of the consort. Others undoubtedly experience sensations fully equal to those of the male. Conception is probably more likely to occur when full venereal excitement is experienced, yet it is by no means conditioned upon such enjoyment, for it may result from connection in a state of unconsciousness. The mechanism of the act closely resembles that of the male. The parts are supplied by a corresponding set of nerves and the circulatory changes are the same in nature. There is a certain degree of erection of the clitoris which causes it to become more acutely sensitive, and of the erectile bulbs at the sides of the vulva. The erectile tissue of the vagina also participates and there may be an ejaculation from the glands of Bartholin opening at the sides of the labia minora. To what extent the higher organs are involved is not definitely known. The uterus sinks lower in the vagina and the cervix is said to become softer. A certain amount of erection takes place in the uterus, by contraction of its muscular fibres and those of the round ligaments, and the cavity is thus reduced in size, causing the expulsion of a few drops of mucus from the os. The subsequent relaxation is supposed to favor the entrance of seminal fluid if it does not in reality draw it in as by aspiration. No one has yet confirmed the descriptions by Litzmann, in 1846, and by Beck, in 1872, of a gasping, opening and closing of the os as a part of the orgasm. For the consideration of the method by which the spermatozoa are carried through the upper passages the reader is referred to the article on *Impregnation.*

The normal frequency of copulation in the female is more difficult to determine than in the male, for desire is more variable and excess as a rule is better borne. There should certainly be a respite, however, during menstruation, in the latter period of utero-gestation, and for several weeks after confinement.

Copulation may be incomplete from various causes; it is not infrequently so in the first experience of either party to it. The undue nervous excitement of the male sometimes ends in a loss of rigidity or in premature ejaculation. An unduly rigid hymen, an undeveloped condition of the vagina, narrowness of the orifice, or other abnormality may prevent entrance.

Various accidents occur. Lacerations and abrasions of the penis are usually of no importance except with reference to the possibility of infection. Œdema or ecchymosis of the skin occasionally follows undue violence. Urethral hemorrhage sometimes occurs, frequently from rupture of a stricture. Cases are reported in which the root of the penis has been dislocated. The so-called fracture consists in a rupture of the corpora cavernosa and may result in such deformity as to render future coitus impossible. Quite a number of cases have been recorded in which the great contraction of the vagina aided by that of the levator ani rendered separation after coitus difficult or impossible until various remedies had been applied. This result seems to have followed the application of musk to the vagina in several instances. More or less complete epileptic seizures sometimes occur during or after connection, most frequently accompanying the orgasm, particularly in the female. Death has also been reported in not a few instances, but its immediate cause has generally been cerebral hemorrhage, the rupture of an aneurism, or it was the termination of an organic disease hastened by the exertion.

The injuries to the female are sometimes serious in character; they are especially liable to occur as a result of the assumption of unnatural positions. The rupture of the hymen is generally of no consequence, but the rent occasionally extends so deeply as to involve the mucous membrane of the vagina and thus give rise to serious hemorrhage. Laceration of the perineum, the clitoris, the urethra, or the anterior vaginal wall into the bladder and similar accidents have been reported. Uterine hemorrhage is not seldom induced, especially by the first connection when it occurs soon after menstruation, and is sometimes of considerable severity.

The medico-legal aspects of this subject will be found under the title of *Rape, Medico-Legal Aspects of.*

James M. French.

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Benjamin Vaughan Abbott.

CORAL BEAN. See *Poisonous Plants.*

CORIANDER.—CORIANDRUM. Coriander Fruit; incorrectly, "Coriander Seed." The coriander plant is an annual European herb, also cultivated in Europe and the United States. It has been so long cultivated that it is scarcely known in an indubitably wild state. The following is the official description of the drug: Globular; about 4 mm. in diameter; crowned with the calyx-teeth and stylopod; brownish yellow, with slight longitudinal ridges; the two mericarps cohering, enclosing a lenticular cavity, and each furnished on the face with two oil tubes; odor and taste agreeably aromatic.

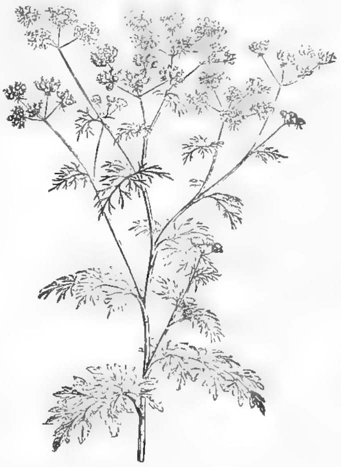


FIG. 1515.—Coriander Plant, one-tenth natural size. (Baillon.)

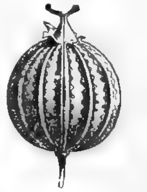


FIG. 1516.—Fruit of Coriander, natural size.

It contains about one-half per cent. of *essential oil*, eleven of *fat* (in the seeds), and fourteen of nitrogenous matters, etc. The only constituent of value is the oil (*Oleum Coriandri*, U. S. P.), a colorless or yellowish liquid, having the characteristic aromatic odor of coriander, a warm, spicy taste, and a neutral reaction, sp. gr. 0.870 to 0.885. *Linalool*, or *coriandrol*, and *pinene* are the constituents.

Coriander is a very mild and agreeable carminative, of the same properties as anise. Dose 2 to 8 gm. (ʒ ss.-ij.); of the oil, ten drops or so—on sugar or suspended in syrup or mucilage. There is no official preparation of either the fruit or the oil, though the former enters into the *Confectio sennæ* and the latter into the *Compound Spirit of Orange.*

W. P. Bolles.

CORIARIA.—A genus (fam. *Coriariaceæ*) of about ten species of shrubs inhabiting warm or tropical regions. The leaves and fruits of several of these are well-known poisons, both to man and to grazing animals. In the ripe fruit, the poison is said to be confined to the seeds. Their medicinal use has apparently not been tried, but they are of interest because the leaves of one, *C. myrtifolia* L., have been found as an adulterant of senna. They are readily distinguished by their three-nerved surface. The active principle is the glucoside *Coriomyrtin* ($C_{30}H_{36}O_{10}$), which is crystalline, tasteless, and soluble in both water and alcohol. Its action is very similar to that of picrotoxin. *Henry H. Rusby.*

CORNEA, DISEASES OF THE.—In order to recognize and understand the various pathological lesions to which the cornea is subject, an accurate knowledge of its anatomy and histology is essential. The term *keratitis* is applicable to all inflammatory processes affecting the cornea and causing certain deviations from its normal uniform transparency,—alterations which are, as a rule, easily recognized by simple inspection with the naked eye; but the method of examination known as focal illumination affords a ready means of detecting changes of slight degree which might otherwise easily escape observation. Structural changes resulting from inflammation are either transitory or permanent. Inflammatory processes in the cornea give rise to various changes in its physical condition, the most constant of which is a loss of transparency which involves the compact fibrillar arrangement of the corneal tissue, and which is caused by the imbibition of fluid material as well as of the more solid cellular elements that have migrated into the cornea from the surrounding vascular system. This subject has been very thoroughly studied by many observers, and the free migration of leucocytes into the cornea from this source is one of the pathological questions which may be regarded as definitely settled. The formation of blood-vessels in the cornea is common to several varieties of keratitis. They owe their origin to the fact that the terminal vessels surrounding the cornea send off-shoots into the corneal tissue and so give rise to a conspicuously vascular condition of this structure, which disappears wholly or in part as the inflammation subsides. The development of these blood-vessels, therefore, belongs to the process of repair. An engorgement of the blood-vessels in the tissues around the cornea is one of the most constant signs of keratitis, and is known as pericorneal congestion.

It is still an open question as to what part the fixed corneal corpuscles take in the inflammatory process. If this has been of such a character as to cause permanent alteration in any part of the cornea, both the fixed corpuscles and the fibrillar structure involved are found to have undergone more or less destruction and elimination. A transformation of the normal clear corneal tissue into white fibrous or scar tissue, which often remains permanently, is a common sequel of corneal inflammation; this is the explanation of most permanent corneal opacities.

The cornea, owing to its exposed position and nonvascularity, is particularly liable to traumatism and to inflammatory processes due to infection and to lessened vitality of the tissues. Three types of corneal inflammation are generally recognized; they are *infiltration*, *abscess*, and *ulceration*.

1. *Infiltrations* are characterized by the presence of leucocytes in such numbers as to cause loss of transparency, with more or less displacement of the fibrous parenchyma of the cornea. Crowding the lacunæ and canaliculi, they may give rise to an ill-defined, streaky opacity, or, when they are accumulated in larger masses, the cloudiness may be more uniform and circumscribed. Notwithstanding this the corneal tissue may remain so far intact as to permit of perfect restoration, when resolution takes place. If, however, the process has been of long duration and considerable intensity, some degree of permanent opacity will result; the migratory cells may indeed become transformed into fibrous tissue (sclerosed), and blood-vessels may become developed in the substance of the cornea as a part of the permanent alteration of its structure. Corneal infiltrations may be superficial or deep-seated, circumscribed or diffuse; and, although the tendency is to recovery without destruction of tissue or loss of transparency, the more unfavorable terminations in sclerosis or ulceration are quite common events, especially if the infiltration has been injudiciously treated with remedies which exaggerate the irritation already existing. Superficial infiltrations of the cornea are apt to cause more irritation than deep-seated ones, on account of the corneal nerve filaments being most abundant toward its anterior surface. This explains why we often see most intense irritation following trivial abrasions of the surface.

2. *Abscess of the cornea* occurs when an infiltration reaches such a degree of intensity that the nutrition of the part is interfered with to the extent of destroying the proper corneal tissue, while the infiltrating elements become transformed into pus cells. The distinctive gross characters of an abscess are its circumscribed appearance and yellowish color. It often gives rise to an accumulation of pus in the anterior chamber (*hypopyon*), presumably in consequence of the fact that the irritant toxins evolved in the inflamed area find their way into the anterior chamber by absorption or transudation (just, for instance, as atropine solution does when dropped into the conjunctival sac), and there excites a purulent iritis or descemetitis. The proof of this lies in the fact that although pyogenic bacteria are as a rule found in abundance in the purulent corneal lesion, there are few if any of these in the accompanying hypopyon. So much of the corneal tissue as may have been actually destroyed can only be imperfectly regenerated; for which reason, more or less of an indelible opacity remains. Then again, as already stated, an abscess near the anterior surface of the cornea is more painful than one that is deep-seated. The duration of corneal abscess is variable; sooner or later the surface is apt to give way, and the abscess becomes transformed into an ulcer. More rarely it breaks through into the anterior chamber.

3. *Ulcers of the cornea*, many varieties of which have been described, all have one feature in common, that is, they are accompanied by loss of substance. They may result from an infiltration or an abscess, or the ulceration may be the primary lesion, commencing as a superficial loss of substance of irregular outline, first of the epithelium, then speedily extending through Bowman's membrane to the cornea proper. Deposits of lymph and pus in the anterior chamber are also quite common in certain types of corneal ulcers. The surface of the ulcer, in its progressive condition, is generally covered with an opaque material, the residue of broken down tissues, while the margins are surrounded with a grayish zone of infiltration. When the healing process sets in, the base of the ulcer becomes cleaner, its margins smooth and rounded, and the peripheral opaque zone less conspicuous. As the healing progresses the ulcer becomes shallower, and its surface smooth and glistening; for at this stage it is partly covered with epithelium which has grown from the margins toward the centre. Beneath this, new tissue is developed, and the excavation due to loss of substance is gradually filled up by the process of cicatrization. There remains, finally, an opaque area of variable depth and extent, from a slight cloudiness (nebula) to a dense white cicatrix of a pearly or tendinous character (leucoma). Corneal ulcers, especially when situated near the margin, frequently become vascularized during the healing process. An ulcer may remain stationary for a long time, or the surface may not attain the level of the surrounding cornea (corneal facet). Sometimes the process of repair is arrested and renewed ulceration takes place. Perforation of the cornea, with adhesion or prolapse of iris, is a common occurrence, in which case the healing process is apt to be followed by yielding of the softer reparative material to the intraocular pressure and the development of a protrusion known as a corneal staphyloma. Extrusion of the crystalline lens is to be feared

in large ulcerations; or the ulcerative process may involve the entire cornea and result in its total destruction; or panophthalmitis may occur if suppuration extends to the internal structures of the eyeball.

INFLAMMATION OF THE CORNEA (KERATITIS, CORNEITIS).—The term keratitis is now generally applied to all forms of corneal inflammation, the different varieties of which have been variously classified. All the more common varieties may conveniently be included under the headings: (1) Superficial keratitis; (2) Parenchymatous Keratitis; (3) Suppurative Keratitis.

Under the first heading are included catarrhal, phlyctenular, vascular, and traumatic keratitis.

Catarrhal ulcers belong to the non-purulent type of keratitis and are of frequent occurrence as a sequel of conjunctival catarrh, especially in elderly persons. The usual seat of the ulcer is at or near the corneal margin in the form of a shallow sulcus of variable length, or there may be several abrasion-like defects of the surface, the extent of which, owing to the absence of infiltration, can be accurately determined only by the use of fluorescine. A moderate degree of pain, circumcorneal redness, lachrymation, and photophobia are usually present. This form of ulcer tends to heal readily unless, as occasionally happens in the presence of purulent secretion from the conjunctiva, the ulcer becomes infected and gives rise to a dangerous purulent keratitis. If symptoms of undue irritation arise during the course of a catarrhal conjunctivitis a careful scrutiny of the cornea must be made with the aid of focal illumination and fluorescence. The treatment consists in the use of remedies suitable for the cure of the conjunctival catarrh, the cautious employment of atropine if irritation be at all severe, and of local disinfectants if infiltration makes its appearance. Of these an occasional application of sublimate solution is most serviceable.

Phlyctenular Keratitis is closely allied to phlyctenular conjunctivitis (see *Conjunctiva*, etc.), and is often associated with a more general conjunctivitis. It commences as one or several superficial infiltrations, of small size, perhaps not larger than the head of a pin or a millet seed, on any part of the corneal surface, from the extreme periphery to the centre. Each little infiltration, circular in outline, is surrounded by a slight zone of opacity, and causes some elevation of the epithelium covering it; if it be in the form of a vesicle this is seldom demonstrable. The epithelial covering is soon shed, leaving a small excoriation of the surface, or a tiny ulceration which occasionally extends, and may assume the more formidable characters and dimensions of a suppurative keratitis—an event usually traceable to improper treatment or to a very defective state of nutrition.

Phlyctenulæ often become vascularized, and, after repeated attacks of this kind, a form of pannus, known as eczematous or scrofulous, may become developed (see section of this article relating to Vascular Keratitis).

More or less pericorneal injection, with other irritative phenomena, sometimes very pronounced, is always present, and is probably due to the fact that the infiltration tends to follow the course of certain nerve filaments (Iwanoff) which then become embedded in exudation corpuscles and other products of inflammation. Intolerance of light, lachrymation, and spasmodic closure of the eyelids are the most conspicuous signs of irritation. Restlessness and pain at night are quite common. Often the eyelids are more or less swollen, and the overflow of acrid secretions causes excoriation of the integument. In this way an eczematous or impetiginous eruption may spread over the integument of the face and head. The subjects of phlyctenular keratitis are usually children, sometimes in apparently good general health; but, as a rule, they are of strumous habit and show other signs of faulty nutrition. In many cases there are obvious signs of nasal catarrh with or without adenoid vegetations in the vault of the pharynx. The relapsing character of the affection is often due to the presence of these complications. An inquiry into the mode of life of these children will usually reveal grave errors in the matter of diet and general hygiene. Any of the ordinary diseases of childhood are apt to be followed by this form of ophthalmia, presumably only in subjects otherwise predisposed to its occurrence. In slight cases, the disease may quickly pass off, leaving little or no trace of its existence; but far more frequently circumscribed opacities remain for a long period, and sometimes for life, as a permanent blemish. When situated over the centre of the cornea such permanent opacities, though apparently slight in degree, may cause serious impairment of vision. The affection tends to relapse and is consequently apt to be of long duration, especially when the infiltrations are remote from the corneal margin. Many young persons are subject to repeated attacks, at intervals, until adult age is reached.

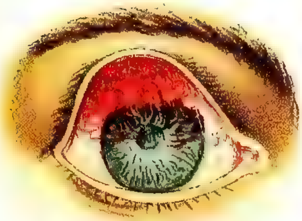
Treatment. So long as there is active irritation, soothing measures are indicated. Solution of sulphate of atropine, gr. ij.–iv. ad ℥ i. in solution of hydrarg. perchlorid. (1 to 5,000), may be instilled two or three times daily. Heat, applied either in a dry or a moist form, for fifteen minutes or half an hour at a time, and several times daily, is a remedy of great value. A warm solution of boric acid, one or two per cent., may also be used freely as a wash, if there is increased conjunctival secretion. Careful cleansing is of importance also in preventing excoriation of the lids. The latter condition may require the use of local astringents, such as the mitigated nitrate of silver crayon, or of ointments containing oxide of zinc, boric acid, and a small quantity of salicylic acid; or the employment of some form of drying powder may be preferred. When there is swelling of the conjunctiva, with hypersecretion, it will be well to touch the everted lids, once every two or three days, with a solution of nitrate of silver, gr. iij.–v. ad ℥ i.; and in doing this the precaution should be taken to wash off the excess of the solution before replacing the lids.

When the irritability of the eye has subsided somewhat, applications of yellow oxide of mercury ointment, gr. x. to xv. ad ℥ i., (a small portion to be placed under the upper eye-lid), or calomel insufflations, may be resorted to once daily, care being taken not to use these remedies in the presence of augmenting irritation. With this precaution their use is likely to be remarkably beneficial. To prevent relapses the ointment may be used once every other day for several weeks after apparent recovery has taken place. Counter-irritants, such as iodine painted over the brow or touching the skin of the upper lid lightly with solid nitrate of silver, are sometimes very beneficial; but the use of blisters cannot be too strongly condemned. Solution of eserine sulphate (gr. ij. ad ℥ i.) is occasionally more efficacious than atropine in relieving pain, blepharospasm, and intolerance of light.

Intense blepharospasm may require canthotomy, and protracted photophobia may often be greatly relieved by forcible exposure of the eyes to strong light for ten or fifteen minutes, by dropping iced water upon the cornea (Oppenheimer), or by dipping the face in cold water. A four-per-cent. solution of cocaine dropped into the eye often affords temporary relief, and seems to assist the action of other remedies. Faulty condition of the naso-pharynx must be remedied by suitable measures, and until this is done a permanent cure is hardly to be expected.

Treatment which has for its object an improvement in the general health is of primary importance. The diet should be simple and wholesome, with strict avoidance of dainties between meals. Occasional small doses of hydrargyrum cum cretâ ("gray powder") with rhubarb at night are often beneficial. Cod-liver oil and syrup of the iodide of iron are favorite remedies in strumous subjects. The employment of quinine is advocated by some authorities: in full doses, at the outset, by de Wecker and others; in small tonic doses during the course of the disease, by Noyes. Tepid or cold salt-water baths, followed by friction of the skin, and clothing suitable for the climate and season, are means which must not be neglected for promoting recovery and for preventing fresh attacks. A change of air, especially a sojourn at the seaside, will often promptly cure when other remedies fail. Plenty of

PLATE XXIV.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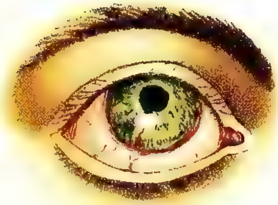
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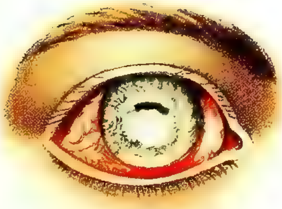
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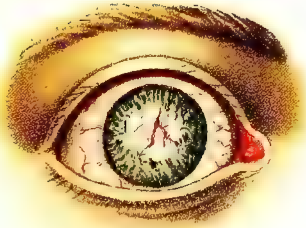
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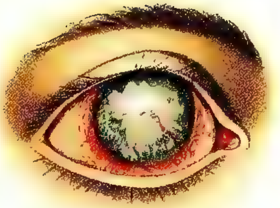
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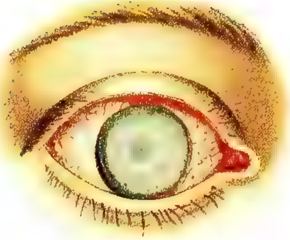
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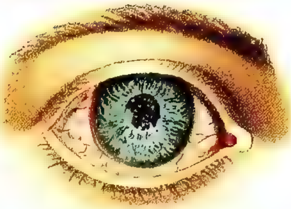
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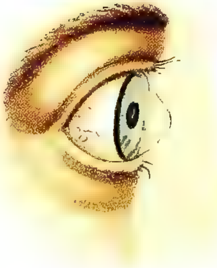
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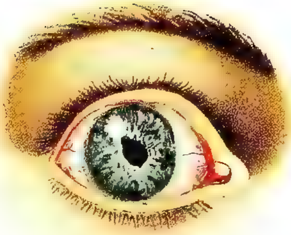
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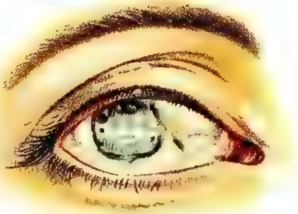
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fresh air and a fair amount of outdoor exercise are indispensable. There can be no greater mistake than the common practice of keeping a child suffering from phlyctenular ophthalmia shut up in a darkened room on account of intolerance of light. When out in the open air the eyes can be sufficiently protected by wearing a large shade. Further protection can, if deemed necessary, be secured by means of a bandage. A firm compression bandage may be of great service if there is ulceration of the cornea. The ulceration may indeed be so considerable as to require the same treatment as suppuration keratitis. The condition in which a circle of exceedingly minute phlyctenulæ surrounds the extreme margin of the cornea is perhaps, strictly speaking, an affection of the conjunctiva. It is apt to be attended with severe irritation and great pericorneal injection, only yielding slowly to treatment, which in the main need not differ materially from the measures just recommended for the purely corneal affection.

A modified form of phlyctenular keratitis, known as *fascicular keratitis,* must also here receive mention, as it is not of infrequent occurrence, tends to run a protracted course, and is often very troublesome. In this form a rather large phlyctenula appears at the corneal margin and slowly advances across its surface, and a leash of blood-vessels follows in the wake of the advancing infiltration, which often has a yellowish color at its most prominent part. Should the band thus formed extend as far as the centre of the cornea, it there curves upon itself and assumes a sort of horseshoe figure. Severe irritation is characteristic of this form of strumous keratitis. A rapid cure of this affection can nearly always be obtained by destroying the infiltration with a fine point of solid nitrate of silver or with pure carbolic acid applied with a pointed piece of wood; such application must be carefully limited to the advancing infiltration. For a few days afterward, mild soothing and cleansing treatment is required. A streak of opacity always persists for a long time after the inflammation has passed away, and is sometimes permanent.

Herpes corneæ is not to be confounded with phlyctenular keratitis, from which it differs widely in symptoms, causation, and pathology, true corneal herpes being undoubtedly identical in character with herpetic eruptions elsewhere.

In this affection one or more small vesicles, containing a *transparent fluid,* form on the surface of the cornea, and leave superficial excoriations when ruptured. Severe neuralgic pains accompany vesication, but may cease when the vesicles give way; they return, however, as often as fresh ones are formed. During the attack, which is almost always unilateral, there is pericorneal injection, and the eye is often extremely irritable. Three forms of corneal herpes are recognized (De Wecker, "Thér. oculaire," p. 169, 1879):—

1. *Herpes catarrhalis,* which occurs in conjunction with catarrhal affections of the air passages.

2. *Herpes zoster corneæ,* which probably depends upon an inflammatory affection of the fifth nerve, and is very often associated with the cutaneous eruption known as zoster ophthalmicus. Intense pain, both preceding and following the corneal eruption, together with local anæsthesia of the parts affected, is characteristic of this affection. Superficial ulceration and infiltration of the cornea, which is slow in healing, is more conspicuous than in the catarrhal form. In zoster ophthalmicus corneal lesions are likely to occur only when the nasal branch of the first division of the fifth is involved, as evidenced by the cutaneous eruption at the corresponding side of the nose.

3. *Herpes idiopathica corneæ* differs from the second variety mainly in its tendency to recur, sometimes periodically, and in not being associated with an eruption of cutaneous zoster.

Treatment. The first variety requires no other treatment than such as may be necessary for other co-existing catarrhal affections. In the second and third varieties hot applications of belladonna or chamomile in the form of fomentations are beneficial, atropine instillations and a compression bandage are also to be employed; large doses of quinine have been found beneficial, and, later on, applications of electricity (the constant current). Arsenic given for a short time in full doses seems to relieve the neuralgic symptoms.

Keratitis bullosa is a rare affection which might readily be mistaken for herpes corneæ, as it is characterized by the rapid formation of transparent vesicles on the corneal surface, which come and go with sudden attacks of severe pain in the eye. In this disease the vesicles are much larger than in corneal herpes; there may be only one large flaccid bleb, 4 to 5 mm. in diameter, or several of these of various sizes. When these burst or are removed, the subjacent cloudy cornea is laid bare, but in the course of a few days the epithelium is restored again, only to undergo a repetition of the process. Again, eyes affected in this way are usually otherwise in an unsound condition. For example, there may be absolute glaucoma or old irido-choroiditis, and under these circumstances the formation of vesicles probably depends upon a disturbance in the lymph channels of the cornea, which is always the seat of chronic interstitial changes—keratitis parenchymatosa (Gräfe-Saemisch, *Ges. Augenhlk.,* vol. iv., p. 272). The treatment of this condition is not very satisfactory in its results: removal of the blebs is only palliative; shaving off a layer of subjacent cornea has been known to prevent their recurrence. The operations of iridectomy and sclerotomy have proved curative in some instances. Enucleation of the eyeball is justifiable as a last resort, and will prove a welcome relief after months or years of suffering.

Vascular Keratitis. Superficial infiltrations of the cornea, with roughness of the epithelial layer, caused by erosions and hypertrophic irregularities of its cellular elements, may occur without obvious reason, or in consequence of repeated attacks of phlyctenular keratitis, or as the result of trachomatous conjunctivitis (Fig. 1, Plate XXIV.). With these changes blood-vessels develop more or less abundantly between the epithelial layer and Bowman's membrane, as well as in the corneal substance immediately beneath,—a combination of lesions that constitute, when the vessels are numerous, the condition known as pannus. Of this two varieties are recognized: *pannus tenuis,* when the new-formed blood-vessels are comparatively few and scattered; *pannus crassus,* when they are so numerous as to give the cornea a distinctly red appearance.

When this process encroaches upon the pupillary area of the cornea, vision becomes correspondingly impaired, being reduced in some instances to qualitative perception of light. In the presence of pannus the eye becomes liable to attacks of an inflammatory character, attended with pericorneal injection, pain, lachrymation, and photophobia. At such times the cloudiness and vascularity are notably increased. The cornea may undergo further changes in the way of ulceration, partial thinning, and permanent alterations of curvature. In any case, after recovery more or less permanent cloudiness remains, as may readily be seen by focal illumination, which also reveals minute permanent blood-vessels too small to be seen by the naked eye.

Treatment. So long as any acute symptoms are present every form of stimulating treatment is to be avoided, but may be resorted to when these have subsided of their own accord or under the use of atropine, warm fomentations, and the frequent introduction of vaseline into the conjunctival sac. The red oxide of mercury ointment is often very efficacious in all forms of the disease, especially in phlyctenular pannus. Tannin and glycerin, or a spray of cupric sulphate, gr. v. ad ℥ i. (Schweigger), are often of service in the pannus of granular ophthalmia. In these cases the conjunctiva will, of course, require suitable treatment, and the pannus as well as the recurring attacks of irritation may disappear with the cure of the granulations. The operation of peritomy may be required for high degrees of pannus, and often yields excellent results. Formerly, inoculation with the pus of ophthalmia neonatorum was much in vogue, and in selected cases of dense pannus was found very satisfactory, but it was always open to the objection that the inflammation once set up could not be controlled, and might prove, as it sometimes did, destructive. Since the introduction of jequirity brilliant results have been obtained by its use, in just such cases as would have been deemed suitable for inoculation. By varying the strength of the solution used and the number of applications the surgeon will experience no difficulty in regulating the intensity of its action. Operations for relieving undue pressure of the eyelids (cantholysis or canthoplasty), or for obviating inversion of the eyelashes (entropion and trichiasis), are sometimes required.

Traumatic Keratitis. See the section that treats of Wounds of the Cornea.

Parenchymatous Keratitis (Interstitial Keratitis) is a form of inflammation characterized by infiltration of the cornea in its entire thickness, without tendency to ulceration or abscess; the whole cornea is more or less involved. The epithelium has a stippled appearance, which, with the subjacent opacity, gives to the cornea, in some cases, a resemblance to ground glass (Plate XXIV., Fig. 6). The onset of the disease is preceded for some days by symptoms of irritability, lachrymation, and slight pericorneal injection. Corneal opacity, either peripheral or central, now soon makes its appearance; the former being attended with the formation of fine, closely set blood-vessels grouped together as a vascular patch, which slowly advances from the corneal margin toward its centre. In this way the entire cornea may become densely opaque and highly vascularized, although in the worst cases a yellowish infiltration occupies its central portions. In another class of cases a central cloudiness of the cornea appears, and, while gradually extending toward the periphery, becomes more and more opaque, but not vascular. Between these two types there are mixed forms; there are others in which the opacity has a patchy appearance, some of the patches being vascularized, while others are not.

The disease runs a slow course and relapses are not infrequent. As a rule, six or eight weeks elapse before it reaches its acme; then, after remaining stationary for some weeks longer, it slowly subsides. Irritative phenomena may last for from three months to a year, while the clearing process is proportionately protracted and rarely terminates in complete restoration of transparency. Symptoms of irritation, with deep ciliary injection, may be very slight or intense according to the severity of the case and the degree of vascularization. Vision is always greatly reduced for the time being; both eyes are likely to suffer, though rarely attacked simultaneously; the interval may be weeks or many months; relapses after partial recovery are not unknown. When the disease is of syphilitic origin the iris nearly always participates in the inflammation, and if a further extension of the disease occurs, there may be iritis or irido-choroiditis.

The disease is always of constitutional origin, and hereditary syphilis is clearly the predisposing cause far more frequently than any other known dyscrasia. Acquired syphilis will account for a few cases. The strumous diathesis is assigned an important place by some observers (von Arlt). The subjects of inherited gout are also said to be liable to this form of keratitis (Noyes).

When parenchymatous keratitis occurs in hereditary syphilis, other well-known signs of this taint are commonly present, especially the so-called syphilitic teeth ("Syphilitic Diseases of the Eye and Ear," by Jonathan Hutchinson). There is then usually a history of one or more abortions or still-born children prior to the birth of the affected individual. The tendency may occur in two or three consecutive children of the same parents whilst those coming later escape. The affection occurs, as a rule, in young persons of from five to twenty years of age, rarely at an earlier or later period of life.

Treatment.—If the disease can be traced to hereditary syphilis, mercury in some form should be administered, preferably a mild course of inunction, which may be continued for a long period if care be taken not to push it so far as to cause or increase debility. It should be omitted for a time the moment the gums begin to show redness and swelling. Iodide of potassium in moderate doses may be resorted to later on. Throughout the course of treatment roborant measures are indicated; existing anæmia is best combated with the syrup of the iodide of iron, though iron with quinine or strychnine may sometimes be found better adapted to the requirements of the case. Cod-liver oil is also a valuable remedy in these cases if the patient is of strumous habit; under these circumstances mercury must be employed with great caution, if used at all. In lieu thereof various preparations of the iodides may be used. Errors of digestion must be corrected with suitable remedies. Good plain food and abundance of fresh air are of course essential means in keeping up the general health. A large shade and tinted glasses may be worn when the patient is in the open air or exposed to strong light. In the local treatment one leading principle is to be steadily kept in view: *No astringent or irritating remedy is to be employed until all signs of active irritation have subsided.* The moderate use of atropine is always indicated during the active stages of the disease. A two- or four-grain solution may be instilled once or several times daily, according to the degree of irritation; in other words, *the pupil must be kept moderately dilated* so long as the eye remains inflamed. Fomentations with hot water or chamomile infusion may be employed for twenty minutes at a time, frequently during the day, until the disease is well on the decline. Used in this way they are said to shorten the course of the disease and mitigate its severity. The presence of conjunctivitis of slight degree does not call for astringent treatment, though solutions of borax and boric acid may be used under these circumstances with benefit. Solution of atropine sometimes sets up a characteristic conjunctivitis, in which case it must be abandoned, and, if necessary, some other mydriatic chosen (duboisine, homatropine, hyoscyamine). Recently the subconjunctival injection, every few days, of mercuric perchloride (1 to 2,000) has been highly extolled by several writers.

Some protracted cases may require an iridectomy (or sclerotomy, De Wecker) before they begin to improve, particularly if there be undue tension of the eyeball. After all irritation has subsided, the careful use of stimulating applications, such as the oxide of mercury ointment, or insufflations of calomel once or twice daily, may assist in removing the residual corneal opacities of parenchymatous keratitis. When this disease occurs in gouty subjects (usually adults), pain and photophobia are prominent symptoms (Noyes). Constitutional remedies suitable to the diathesis are to be administered. Muriate of pilocarpine (gr. $\frac{1}{8}$ to $\frac{1}{4}$ by hypodermic injections, once daily) is also recommended, particularly if atropine instillations are not well borne. The local treatment must be of the soothing character already mentioned. Paracentesis of the cornea is also useful in relieving pain if there is obviously increased tension of the globe.

Suppurative Keratitis is a term applicable to all inflammatory affections of the cornea which are attended with purulent infiltration, and it includes abscess of the cornea as well as several forms of corneal ulceration. Either abscess or ulcer may originate spontaneously, or as the result of some, perhaps, trivial injury; either may commence as a simple infiltration, or the formation of pus may take place from the outset. Every case of suppurative keratitis is probably the result of infection of some wound or lesion which has permitted the entrance of disease germs beneath the normal protective barrier which the strong corneal epithelium furnishes. Debility and malnutrition diminish the patient's power of resistance and so favor the suppurative process. Pneumococci, staphylococci, and streptococci are the common forms of disease germs met with in suppuration of the cornea, and it must be borne in mind that these are also commonly present in the normal conjunctival sac; hence the necessity for strict asepsis in all corneal wounds.

Deposits of pus in the anterior chamber (Plate XXIV., Fig. 3), called *hypopyon*, are of common occurrence in suppurative keratitis. The occurrence of this phenomenon has been accounted for in several ways: (1) The pus cells may travel through the posterior corneal layers and Descemet's membrane (Horner); (2) or they may pass between the layers of the cornea on to its lower periphery, reaching the anterior chamber through the interstices of the ligamentum pectinatum (Stromyer); (3) by direct rupture of a corneal abscess, the pus may escape into the anterior chamber; (4) the epithelial cells of Descemet's membrane may undergo purulent proliferation; (5) as already stated, an associated purulent iritis or iridocyclitis induced by the transudation of irritant ptomaïns from the suppurating cornea to the interior of the eye may contribute to the formation of pus in the anterior chamber, or it may perhaps wholly account for the phenomenon.

Whatever its origin, the purulent mass in the anterior chamber may be of a semi-solid or gelatinous consistence, and so cohesive as to admit of being withdrawn bodily from the chamber after an incision sufficiently large for an iridectomy has been made.

Suppurative affections of the cornea attended with hypopyon are either sthenic, with great pain and inflammatory symptoms of an active character, or asthenic and sluggish, with little or no pain, etc. The latter are indicative of a very low state of nutrition, or of torpor of the fifth nerve. A circumscribed purulent infiltration of the cornea without superficial loss of substance constitutes an abscess and may be attended with hypopyon, etc., so long as the disease does not advance beyond this stage; but sooner or later the surface is likely to give way, and the abscess then becomes an ulcer. Whenever hypopyon results from suppurative keratitis the corneal lesion always presents more or less of a dull yellow color, caused by infiltration of the part with pus cells. In the sthenic form there are pain, often intense, deep-seated injection of the eyeball, photophobia, and lachrymation. The appearance of the cornea varies according to the extent of the disease and its mode of progress. The sthenic abscess or ulcer is surrounded with a zone of gray infiltration, sometimes of a streaky appearance; the ulcerated surface may be excavated or nearly on a level with the surrounding cornea; its surface is always more or less covered with a layer of grayish or yellowish-gray broken-down material. Pus in the anterior chamber may appear at its lower edge as a narrow yellow streak, a wide space of clear cornea intervening between this and the lower edge of the ulcer or abscess; or a streak of purulent deposit behind the cornea or between its lamellæ may extend from the ulcer to the hypopyon. A large accumulation in the anterior chamber may extend to the level of the ulceration, so that they appear to blend with each other. Perforation of the cornea, with or without prolapse of the iris, may occur before the ulceration has extended very widely; or the ulceration may involve so much of the cornea that it becomes transformed into a dull yellow necrotic mass. The term *serpiginous corneal ulcer* has been applied by Saemisch to those "forms of suppurative keratitis which are distinguished by the tendency to penetrate into the parenchyma and extend superficially, especially in one direction." Such ulcers are apt to progress, sometimes rapidly, and may prove very destructive.

Eyes subject to chronic conjunctivitis, with blennorrhœa of the lachrymal sac, seem particularly prone to destructive suppurative keratitis, probably owing to the continued presence of septic material in the conjunctival sac. Purely asthenic suppurative keratitis commences as a rule about the centre of the cornea. In this affection all signs of active inflammation are wanting; the absence of a gray zone of infiltration around the suppurating area is also to be noted; and the surrounding cornea may even appear unusually pellucid, only becoming infiltrated and cloudy when healing has commenced. The changes which take place during the healing of corneal ulcers have already been briefly described; we may here add that with this, in asthenic cases, a certain degree of irritation develops, whilst in the sthenic forms the existing sthenic irritation tends to subside.

Treatment.—Rest and protection of the eye are of primary importance; both these indications are best secured by the judicious use of a compression bandage. The eye must also be kept free from unhealthy secretions, by washing several times daily with a warm two-per-cent. solution of boric acid, or with a solution of formalin, 1 to 2,000. In addition to this, the moderate use of warm-water fomentations, or warm carbolic lotion, 1 to 1,000, followed by instillations of solution of atropine (gr. iv. ad ℥i.) will be necessary. This measure will often arrest the suppurative process in its early stages, the ulcer taking on a healing action, and the hypopyon rapidly disappearing. Should a fair trial of this treatment fail to arrest the disease, and especially if the ulceration, etc., continue to increase, a more energetic interference will be necessary. Scraping the ulcerated surface with a small sharp scoop and then carefully applying the actual cautery is the most efficient means of local disinfection. Division of the ulcer according to the method of Saemisch is preferred by some to the cautery, and it is quite true that if the corneal destruction has not progressed too far, say not beyond one-third of the extent of the cornea, this operation will often suffice to stay the destructive process. Opening the anterior chamber allows the escape of its purulent contents, and, by relaxing the tension of the cornea, promotes its nutrition. The performance of this operation is now greatly facilitated by placing the eye under the local anæsthetic influence of cocaine. The Saemisch operation is performed as follows: The narrow cataract knife of von Graefe is made to penetrate the sound cornea, close to one margin of the ulcer, behind which it passes to emerge in a similar position at the opposite side of the ulcer, care being taken to avoid the iris and lens; the contents of the anterior chamber escape through the opening. If the exudation be partially tenacious, the use of the iridectomy forceps may be required to remove the tenacious coagulum from the anterior chamber after the operation.

Borated lint, to be retained on the eye with a compression bandage, may be kept applied until the next day; after this, repeated fomentations with a warm solution of boric acid (1 to 30) or formalin (1 to 2,000) will be required. Under this treatment, the plan recommended by Saemisch, of reopening the wound daily with a small probe until the ulcer becomes clean, will be found unnecessary (Noyes). Or the operation may be followed by instillations of eserine (one-half-per-cent. solution) several times daily (De Wecker), instead of by further instrumental interference.

If the necrotic process is arrested, the ulcer will become clean and will slowly heal, perhaps with adhesion between iris and cornea if the ulcer has been large, in which case also a staphylomatous bulging may occur and require appropriate treatment. In many cases more or less of a permanent scar will remain, often a dense leucoma, with impairment or complete loss of vision. Total destruction of the vision will sometimes occur despite all treatment, especially if panophthalmitis develops; the ruined eye, under such circumstances, may be eviscerated in order to save the patient from the long period of suffering which would attend suppurative inflammation of the eyeball. Enucleation of a hopelessly suppurating eyeball involves some risk of being followed by septic meningitis and for this reason simple evisceration is to be preferred. In suppurative keratitis a tonic treatment is always indicated, and in the asthenic forms stimulants can be used with benefit, and the hygienic conditions must be made as favorable as possible.

Ulcers of the cornea, not associated with hypopyon, are of frequent occurrence. They vary much as to appearance, situation, course, duration, and importance; they originate from abrasions or injuries of various kinds, from the injurious effects of certain morbid conditions of the conjunctiva or other diseases of the eye, and from defective states of nutrition generally. They may be superficial or deep, clean and smooth, with rounded edges and no surrounding infiltration, or irregular in outline, with opaque gray or yellowish-gray surface, and steep or excavated edges, and well-marked surrounding zone of infiltration. They may be situated at the extreme corneal margin or may occupy any part of its surface, remain stationary or extend in depth and area, and last only for a few days or become chronic. So long as an ulcer remains small and superficial, without encroaching on the centre of the cornea, it is not likely to be of serious importance. There may be very little pain and irritation, or acute symptoms may characterize the affection from the outset, such as severe pain, great pericorneal injection, intolerance of light, and profuse lachrymation.

Small, deep ulcers at the corneal margin, of a yellow color, and tending to perforate and cause a peripheral prolapse of iris, are not uncommon; they sometimes partake of the character of a strumous keratitis—that is, they originate as phlyctenulæ in a strumous subject,—or they may occur in otherwise healthy subjects. The attendant inflammatory symptoms are of an acute character, and soothing treatment will be essential so long as this condition lasts. Catarrhal and purulent affections of the conjunctiva are often attended with ulceration of the cornea. In the former, the ulcers are usually small, and peripherally situated; they do not require any special treatment beyond that adapted for the conjunctivitis, but may necessitate some care in the use of astringent collyria. Solutions of atropine may be used if the eye becomes more than slightly irritable or painful.

Ulceration of the cornea which occurs in the course of a purulent ophthalmia, especially if this be of gonorrhœal origin, is only too often a disastrous complication, as it frequently causes hopeless destruction of the cornea. The earlier its occurrence in the course of the blennorrhœa the more serious is likely to be the result. The worst form of ulceration is that which makes its appearance about the centre of the cornea as a diffuse gray infiltration, while the conjunctival inflammation is at its height or is still increasing. Such infiltrations rapidly become extensive erosions, and the cornea sometimes melts away, so to speak, in the course of a few days. Furrow-like marginal ulcerations, without much infiltration of their edges, though likely to result in perforation and prolapse of iris, are not nearly so dangerous. In addition to the continuance of energetic treatment suitable for purulent conjunctivitis, warm antiseptic fomentations are required and the conjunctival sac should be frequently filled with vaseline containing three or four per cent. of iodoform or aurol or boric acid, or one-half per cent. of carbolic acid. If perforation is threatened, the instillation of a solution of eserine (1 to 100) every two or three hours, and paracentesis of the chamber through the ulcer, may be found necessary.

A small, transparent, central ulceration is rather common in early life (absorption ulcer). It may occur under the same conditions as phlyctenular keratitis. The ulcer may be overlooked unless a careful examination is made; its symptoms, both subjective and objective, being comparatively trivial. There is some weakness of the eye with slight intolerance of light and lachrymation, especially in the morning. It is a chronic affection, and, after healing, leaves an opacity which, from its central position, may cause permanent impairment of vision. The treatment should be partly soothing and partly stimulating, with measures to strengthen the general health. Somewhat similar small, deep ulcerations, tending to perforate, are met with occasionally in other parts of the cornea in children as well as adults. Such ulcers, when involving pretty much the whole thickness of the cornea, may present a clear, bead-like projection in the centre, caused by protrusion of the unruptured Descemet's membrane into the ulcer. For this condition the term keratocele has been applied. Only after spontaneous rupture, or artificial opening of the part, can such ulcers be brought to heal. They may give rise to a troublesome corneal fistula, especially if allowed to rupture spontaneously.

Crescentic ulcers, forming a deep groove around the periphery of the cornea, and without infiltration, are occasionally seen in elderly debilitated subjects. They are destructive if allowed to progress so far as to cut off nutrition from the central portions of the cornea, which may then exfoliate. The operation of iridectomy is the most efficient means of arresting the progress of such ulcers.

Active inflammatory symptoms are present in the vast majority of corneal ulcers; superficial ulcerations being, as a rule, more painful than those which have extended deeply into the cornea, owing to the fact that the terminal filaments of the corneal nerves are at the surface. The asthenic type is, however, not uncommon in simple ulcers; these have a tendency to spread superficially, and are sharply defined with little or no surrounding infiltration. It is to be remembered that ulcers of the cornea, especially when large, may have extended more deeply than appears to be the case, on account of the intra-ocular pressure pushing the thinned base of the ulcer forward. Such a condition always constitutes a serious obstacle to healing, and forms a positive indication for operative interference. Spontaneous perforation should never be permitted if it can be prevented, because it increases the liability to prolapse of iris and permanent anterior synechia (as in Fig. 9, Plate XXIV., where a perforating ulcer has healed with the iris adherent to the cornea, and the pupillary aperture is drawn up to the corneal opacity). Such an eye is always damaged in vision, disfigured, and more liable to deep-seated disease than if healing had occurred without synechia, or prolapse of iris had taken place; it is also liable, even if the perforation be a small one, to deposits of lymph on the lens capsule, or to rupture of this structure, and perhaps to other intra-ocular lesions.

In the *treatment* of corneal ulcers, their progress and the effect of remedies employed must be scrupulously watched. The use of a compression bandage is generally indicated as a protection from external irritation, and for the purpose of securing rest, so essential to the healing process. The use of atropine instillations is generally indicated. The atropine should be absolutely pure neutral sulphate, and the solution (to be sterilized by boiling once daily) should be of the strength of from two to four grains to the ounce. For allaying irritation and keeping in check iritic complications, which are apt to occur in many corneal inflammations, it is the standard remedy. Cocaine, however, is positively contraindicated in most corneal ulcers.

Solutions of eserine are of considerable value in certain cases of corneal ulceration, more particularly those which belong to the asthenic type; if, however, a tendency to, or actual, iritis be present, eserine may act very injuriously. Warm fomentations are, as a rule, beneficial in allaying irritation and promoting the nutrition of the cornea, but in the presence of active irritation they must be employed cautiously, for fear of unduly increasing this condition. If ulceration is associated with conjunctival disease, which requires the use of astringents, the cornea must be carefully protected from their action. When the healing process is well established, especially when the ulcer is becoming vascularized (Fig. 2, Plate XXIV.), and also in some chronic indolent ulcers, stimulation in the form of oxide of mercury ointment, calomel insufflations, or strictly localized applications of nitrate of silver solution (2–4 to 100) may be employed with advantage. Opiates at night, in doses sufficiently large to allay pain, are often of great service. The electric cautery in the form of a small platinum point heated to a cherry red, answers well the purpose of destroying the infection of suppurative keratitis. The end of a knitting needle heated in a spirit lamp, may be used for the same purpose with equally good effect. Without defining the precise limits of its usefulness, we may say that the procedure has gained a substantial reputation in ocular therapeutics. So much of the cornea as shows a yellow infiltration should be cautiously destroyed by the cautery. Excellent results have also been obtained by touching the ulcer, in certain cases of suppurative keratitis, with pure carbolic acid.

Neuroparalytic keratitis in its objective symptoms does not differ materially from ordinary asthenic inflammatory affections of the cornea. It may never pass the stage of infiltration, but is very liable to become suppurative. Photophobia is absent and there is little or no pain in the eye; the circumcorneal congestion is of a dusky, sluggish character; but the characteristic feature is loss of sensibility of the cornea, and with this there may be anæsthesia of other parts supplied by the fifth nerve.

Treatment.—The first essential is thorough cleanliness; a protective bandage may be used with advantage, borated cotton being placed next the eye, which must be cleansed with warm boric acid or other mild antiseptic lotion several times daily. Eserine instillations are strongly recommended by some writers, and if there is paralysis of the fifth nerve, the galvanic current (from six to eight elements) is likely to be of service, the positive pole being placed over the superior cervical ganglion of the same side, and the negative over the brow or eyelids.

Corneal opacities are commonly the result of some one or more of the morbid conditions already described. When they are the result of perforating ulcers of the cornea, anterior synechia (adhesion of the iris to the cornea) is often present. They tend to grow less marked with the lapse of time, but whatever opacity remains at the end of a year or two after the cessation of the inflammatory process which caused them, may be considered permanent. The effect on vision varies with the degree and extent of the opacity, although slight, almost invisible central clouding may seriously impair vision by causing dispersion of light and irregular astigmatism. The extreme degree of opacity indicated in Fig. 4, Plate XXIV., represents a large central leucoma adhærens, which has become vascularized, the pupil being completely obliterated, and the anterior chamber rendered very shallow. For large opacities encroaching on the pupil an iridectomy, by bringing the pupillary aperture opposite a clear portion of the cornea, may improve vision very considerably, provided the parts beyond are in a fairly normal condition.

The appearance of the eye may likewise be greatly improved by the operation of tattooing with India ink any dense cicatricial opacity. For this purpose a group consisting of several fine needles set in a handle are to be smeared with a thin paste of the ink, and the white tissue of the cornea punctured obliquely until it retains a sufficient amount of the pigment to hide the opacity. While a single sitting often suffices, in other cases several may be necessary. The operation can be rendered painless by the use of cocaine, and is seldom followed by any considerable reaction. The local use of medicinal agents is of problematical value in clearing up cicatricial opacities of the cornea. Other things being equal, the younger the subject the greater is the power of repair in this respect. A large loss of substance in the cornea of an infant will often disappear almost entirely, though the same amount of destruction in an adult would leave a conspicuous permanent opacity.

The stimulating remedies already mentioned are generally conceded to assist in clearing up recent opacities, by temporarily increasing the blood supply in the circumcorneal vessels and thus promoting the functions of nutrition and absorption in the corneal tissue. Of these remedies the most efficient is the oxide of mer cury ointment, gr. i. to ij. ad ʒ i., a small portion of which is to be introduced beneath the upper eyelid once daily. The constant current of electricity, the negative pole being applied to the cornea by a specially constructed electrophore, has been used with some success. The application is decidedly painful even when cocaine is used and care must be taken to employ only a weak current. When the cornea has been entirely replaced by opaque tissue, vision is of course destroyed under these circumstances. Attempts to restore vision by transplantation of transparent cornea to replace the opaque tissue have met with only limited success (Wolfe, *Medical Times and Gazette,* November 22, 1879).

Transverse opacity of the cornea (Fig. 10, Plate XXIV., after Haab) in the form of an opaque band of a gray or yellowish color, 2 or 3 mm. in width and corresponding in position to the palpebral fissure, is sometimes seen in elderly or prematurely senile persons, or in eyes affected with chronic deep-seated disease, and having a tendency to glaucoma (von Graefe.) In the latter form the opacity is made up of minute specks situated deeply in the cornea. The transverse opacity observed in elderly people is due, according to Nettleship, to minute calcareous crystals lodged beneath the epithelium.

Lead stains often occur, in the form of dense white, sharply defined opacities, after the use of lead lotions in abrasions or ulcerations of the cornea; they may be cut away with a thin sharp knife, or scraped off with a small sharp scoop. Collyria containing lead, if used at all in ophthalmic practice, should never be entrusted to the patient for use at home.

Fine punctate opacities, looking, under a strong magnifying glass, like minute drops of tallow, and arranged in the form of a pyramid with its base at the lower corneal margin (Fig. 7, Plate XXIV.), are characteristic of the so-called serous iritis which occurs quite frequently as an idiopathic affection, and occasionally as the serous form of sympathetic ophthalmia. With these are associated more or less turbidity of the aqueous humor, discoloration of the iris, circumcorneal injection, and sometimes posterior synechia; larger opacities (infiltrations) may also develop in the substance of the cornea. Vision is apt to be considerably impaired in these cases. The fundamental lesion appears to be a serous irido-choroiditis, which, by extending along the lymph channels, may involve the *endothelium* of the entire uveal tract and the sheath of the optic nerve as well as that of the cornea.

Sclerosing opacities in the peripheral portions of the cornea sometimes occur without inflammatory symptoms, or as the result of localized sclerotitis passing over to the adjacent parts of the cornea.

Arcus senilis (gerontoxon), a peculiar marginal opacity, has been considered in Volume I.

Pterygium (Fig. 10, Plate XXIV.) has also been considered under the heading of *Conjunctival Diseases.*

Fistula of the Cornea.—Penetrating wounds and ulcers which have perforated the cornea occasionally fail to heal, and consequently there remains a small aperture through which the aqueous humor constantly leaks away, or, if temporarily retained, is repeatedly evacuated by rupture of the thin retaining membrane. Such eyes are always more or less irritable, and liable to attacks of inflammation, which sometimes results in panophthalmitis. According to de Wecker (*Annales d'oculistique,* lvi., 305), the fistula is due to an eversion of the membrane of Descemet, which thus comes to serve as a lining to the walls of the fistulous track, and he recommends that it be lacerated with a fine pair of forceps, or that the aperture be converted into a crucial incision by means of delicate, smooth-pointed scissors. After either of these manipulations, which demand strict antiseptic precautions, atropine instillations and a compression bandage will be required until the part shall have healed firmly. The prolonged use of eserine and the compression bandage has also been found beneficial.

MALFORMATIONS OF THE CORNEA, CONGENITAL AND ACQUIRED.—Congenital defects of the cornea present deviations from the normal in regard to size, shape, and transparency. The cornea may be smaller than normal, as in C. microphthalmos, or larger, as in C. megalophthalmos. Important structural abnormalities in the interior of the eye are present in both these conditions, in all or nearly all such cases (Manz: "Handb. d. gesammt. Augenheilkunde," Graefe u. Saemisch, Band ii., 131).

The cornea of microphthalmos is small and may be flattened, or its curvature may be the same as that of the sclerotic. The latter structure often encroaches upon the cornea; their mutual relations as to size present considerable variations. In outline the cornea may be nearly circular, distinctly oval, or quite irregular. In congenital megalophthalmos the cornea is actually and relatively too large, but at the same time thinner than normal. This thinning involves also the anterior portion of the sclerotic, which thus acquires a bluish appearance, and the anterior chamber is increased in depth and width (hydrophthalmos anterior). Diffuse or circumscribed opacities of such corneæ are often present. The condition just described does not, as a rule, remain stationary, but goes on slowly increasing after birth, and the entire eyeball often becomes enormously enlarged.

Congenital faults in the curvature of the cornea, without anomalies as to size or structure of the eyeball, are of frequent occurrence, and account for a large proportion of the errors of refraction known as astigmatism.

Congenital opacity of the cornea may be partial or complete, apart from the congenital opacities of microphthalmos and megalophthalmos. A condition resembling arcus senilis is sometimes seen at birth (embryotoxon) (Manz, *loc. cit.*). A form of opacity so complete as to give the impression that the cornea is entirely absent has also been observed.

Dermoid cysts involving the cornea are always congenital (see, further on, the section relating to Tumors of the Cornea).

The progress of hydrophthalmos anterior may sometimes be arrested by the operation of iridectomy. If vision is destroyed and the enlarged eyeball is the source of disfigurement and annoyance, a staphyloma operation may be advisable or the Medes operation of evisceration and insertion of an artificial vitreous may yield an excellent cosmetic result.

Conical cornea (*transparent anterior staphyloma*) (see Fig. 8, Plate XXIV.) is a somewhat rare condition, which is said to develop, as a rule, about the age of puberty, or a little later, and more often in the female than in the male sex. Nothing definite is yet known in regard to its causation. Without any other pathological manifestations the cornea gradually becomes thinner at its central part and assumes a more or less conical shape, and, though usually retaining its normal transparency, in high degrees of conicity the apex occasionally becomes clouded. In slight degrees the diagnosis is readily made by means of the modern test (skiascopy) or by the aid of Plundo's disc. At first the eye may become somewhat short-sighted, but vision remains subnormal, even when the error of refraction has been as far as possible corrected with concave and cylindrical glasses. In advanced conditions a profile view of the cornea at once determines the nature of the difficulty. By mirror illumination the optic nerve and retinal blood-vessels appear distorted, rapidly changing in apparent size and shape with every movement of the mirror. Vision is commonly impaired in proportion to the corneal alteration; sometimes to such an extent that only large print can be deciphered.

Treatment. If vision can be materially improved by any combination of glasses, these may be used; not infrequently quite strong cylindrical glasses will be accepted. But if such optical means fail to improve vision, and if the latter be so defective as to justify surgical interference, the apex of the cone may be cauterized with a fine electro-cautery point, thus destroying a limited central area of corneal tissue down to Descemet's membrane. When the central ulcer thus produced has healed, under suitable treatment (see Suppurative Keratitis), the cornea will have acquired a more normal curvature. An iridectomy may be required after this operation. Lateral displacement of the pupil by iridodesis, as recommended by G. Critchett, has not met with much favor on account of the danger of sympathetic mischief which it involves.

Staphyloma of the cornea (opaque anterior staphyloma) (Fig. 5, Plate XXIV.), as already stated, results from ulceration of the cornea with perforation. The perforation must have been of considerable size to be followed by the bulging forward of new scar tissue, which constitutes staphyloma. According to Saemisch, an aperture in the cornea of less than 2½''' is not likely to cause staphyloma. Narrow perforations are less likely to give rise to this condition than when the aperture is rounded. Corneal staphyloma may be partial or total. When a large perforation occurs, the aqueous humor escapes, and the iris comes in contact with the opening and may protrude. Thus exposed, it speedily inflames and becomes covered with lymph which undergoes organization, and a weak cicatrix is formed which yields before the intra-ocular pressure, thus increasing the degree of protrusion. The cornea at the circumference of the aperture, softened by the inflammatory process, also yields to the pressure from within, and becomes involved in the staphyloma, which, at first of small size, may gradually involve a large part of the cornea if measures are not taken to arrest its development.

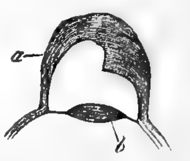

FIG. 1517.—Corneal Staphyloma, natural size. (After Saemisch.) *a*, Cicatricial tissue; *b*, crystalline lens.

In other cases extensive destruction of the cornea gives rise to a bulging cicatricial formation, which from the outset involves the greater part of the corneal area. Very large perforations are, however, apt to lead to extrusion of the lens and shrinking of the anterior part of the eyeball (phthisis anterior). The new-formed tissue which constitutes the front wall of the staphyloma becomes densely opaque, and is often considerably thicker than the original cornea, or thicker in some parts and thinner in others (see Fig. 1517). Its surface is covered with an irregular layer of epithelium, while the disorganized and attenuated iris, often reduced to a few shreds of pigmented tissue, imperfectly lines it internally. The lens becomes dislocated forward (Fig. 1518) and opaque, and often undergoes partial absorption. When very large the staphyloma leads to stretching of the anterior portion of the sclerotic, obliteration of the pericorneal sulcus, and elongation with thinning of the ciliary processes (see Fig. 1519). Disturbance in the normal relation between the functions of secretion and absorption of intra-ocular fluids, with a tendency to glaucomatous tension, is a constant result of staphyloma. A form of consecutive glaucoma sets in, and secondary changes in the choroid, retina, and optic nerve finally reduce vision to quantitative perception of light, or destroy it entirely. This is likely to be the result even when the staphyloma involves only a small portion of the cornea.

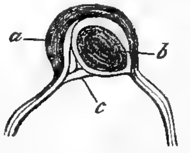

FIG. 1518.—Corneal Staphyloma, natural size. *a*, Cicatricial tissue; *b*, dislocated lens. (After Saemisch.)

Treatment. To prevent the formation of staphyloma, prolapsed iris should be removed; instillations of eserine, with the use of a firm compression bandage, are then in order until cicatrization is completed. If this fails, or if healing has already taken place, with the formation of a partial staphyloma, the question of performing an iridectomy is always to be considered, and a decision in favor of the operation is to be given when there is sufficient clear cornea to permit of the operation, when there is evidence that the trouble is progressing, and when there is increased tension of the eyeball. Under these circumstances a broad iridectomy may be of great optical advantage, and will usually arrest the progressive and destructive tendencies of the disease.

In other cases of incomplete staphyloma there may be no hope of improving vision by an iridectomy, but the deformity may be so considerable as to render an operation desirable for its cosmetic effect. Under these circumstances an elliptical piece may be removed from the projection, the lens if present evacuated, and the edges of the wound brought together with two or three fine sutures. Or a compression bandage

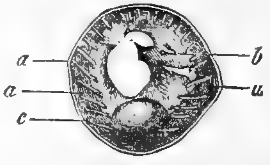

FIG. 1519.—Posterior View of a Corneal Staphyloma, natural size. *a*, Elongated ciliary processes; *b*, remains of the iris; *c*, dislocated lens.

without sutures may be used until the wound has healed.

For total staphyloma, abscission of the entire projection, or evisceration or enucleation of the eyeball, with or without the insertion of an artificial vitreous, is the best means of doing away with the deformity, trouble, and annoyance which it causes. The first is to be recommended when the eyeball is otherwise fairly healthy. Various methods of performing the operation have been devised. In any case, the lens must not be allowed to remain in the eye after removal of the staphyloma.

Critchett's operation of carrying several curved needles armed with sutures through the ciliary region before abscinding the staphyloma, is objectionable on account of the danger of injuring some of the ciliary nerves, and thus exciting sympathetic inflammation; and also because it is liable to be followed by suppuration of the remaining portion of the eyeball.

A less objectionable method is that of Dr. H. Knapp (*Arch. f. Ohr.*, Bd. xiv., 273). Before abscission is performed, the conjunctiva is dissected back for some distance around the base of the staphyloma, and a sufficient number of sutures are inserted to bring the edges of the conjunctiva together over the opening. Evisceration or enucleation is to be recommended in old and large staphylomata with considerable distention and thinning of the adjacent sclerotic, as in such cases abscission is almost sure to be followed by hemorrhage or deep inflammation.

Tumors of the Cornea seldom, if ever, take their origin in the cornea itself, but extend to this structure from adjacent parts, usually the episcleral tissue around the cornea. Dermoid tumors, probably always congenital, are situated partly on the sclerotic and partly over the cornea. Such a growth is smooth or slightly lobulated, pale or yellowish white in color, more or less prominent, and usually, though not always, remains stationary. Its dermoid character is assured if one or more hairs are found growing from the surface. When removed, dermoid growths are not likely to recur. If large enough to cause conspicuous disfigurement, excision of the growth is advisable, care being taken not to penetrate the cornea or sclerotic.

Sarcoma, usually pigmented and consequently of a dark color, may develop from the ciliary portion of the sclerotic and extend to the cornea. The growth is more likely to extend deeply into the sclerotic than into the cornea.

Melano-carcinoma sometimes grows from the same region and covers the cornea, spreading beneath the epithelium. The mass is of a dark color, soft, and vascular.

Epithelioma, commencing at the limbus as a small nodule resembling a phlyctenula in this situation, may remain for a long time inactive, but sooner or later it begins to grow rapidly. The age of the subject and the persistence of the nodule in its early stage are of diagnostic importance. Tumors, such as these involving the cornea, should always be removed with as little delay and as thoroughly as possible. If the operation involves penetration of the eyeball, enucleation will probably have to be resorted to; and this is also necessary when the growth recurs and cannot be removed again completely.

Frank Buller.

CORNIFICATION.—The process of cornification is a physiological change by which the superficial cells of the epidermis acquire a horn like character. It is also found normally in the corpuscles of the thymus. The albumin of the squamous cells of the deeper layers of the epidermis gradually becomes changed, as the cells approach the surface, into a resistant modified albuminous body which possesses a hyaline homogeneous composition resembling that of bone. To this horny substance the name of keratin has been given. Under normal conditions the horny change first appears in the stratum granulosum, involving first the periphery of the cells and the prickle processes. As the change advances the cell protoplasm and the nuclei shrink until the cell bodies become thin and flattened horny scales. The nuclei at the same time gradually lose their staining power, and the entire process assumes the character of a mummification necrosis, the water of the cells being almost entirely lost. Keratin resists digestion by both stomach and pancreatic juices.

In association with the formation of keratin small bodies of a hyaline nature appear in the prickle cells. These granules stain deeply with nuclear stains. In all portions of the epidermis where the stratum corneum is well developed the cells containing these granules form a definite layer known as the stratum granulosum. The substance of the granules has received the name of keratohyaline, and is believed to be derived from the nucleus. As the nucleus disappears with the formation of the granules, the latter may be supposed to be degeneration products of the nuclear chromatin. The chemical nature of cornification and of the two substances, keratin and keratohyalin, is not as yet clearly understood. By some the change is believed to be of the nature of a reduction, and not an oxidation process; but all theories and explanations are as yet unsatisfactory.

Cornification occurs pathologically in a great variety of conditions and under many forms. A hyperplasia of the horny layer of the entire body or of smaller areas frequently takes place (hyperkeratosis). This may be the result of external influences, as mechanical injury, infection, inflammations, etc. (corns, icthyotic warts, callosities, etc.), or the change may be of intrinsic origin due to some congenital predisposition (ichthyosis). Disturbances of the normal processes of cornification may also take place (parakeratosis), such as scaly or plate-like desquamation which may occur in connection with infections or inflammations of the skin, or rarely without any apparent cause. In such cases the formation of keratin and keratohyalin appears to be unchanged. Pathological cornification also occurs in parts of the body where under normal conditions the horny change takes place only to a very slight extent or not at all. The epithelium of the skin glands may be involved in the hyperkeratosis of ichthyosis. Also in the mucous membranes of the mouth, tongue (hairy tongue), larynx, trachea, bronchi, middle ear, mastoid cells, pelvis of kidney, ureters, bladder, urethra, vagina, and cervix uteri a pathological cornification may occasionally take place. The epithelium of the vaginal portion of the cervix may acquire a very thick horny layer in prolapse of the uterus, when the cervix protrudes beyond the external genitals.

In cholesteatomata, teratomata, and dermoid cysts pathological cornification may take place on a very large scale. The so-called "pearly bodies" are for the greater part made up of keratin. Horny change also occurs extensively in epitheliomata of the skin ("epithelial pearls"), forming large laminated masses in which calcification not infrequently takes place. Similar bodies are found in cholesteatomata of the brain and meninges, and horny change has been reported to occur very rarely in carcinomata of the internal organs. Changes similar to cornification have also been observed in endotheliomata of various organs, especially those primary in lymph glands; but the chemical identity of these changes with the cornification of epithelial structures is not settled.

Aldred Scott Warthin.

CORN-SILK.—Zea. *Stigmata Maidis.* "The styles and stigmas of *Zea Mays* L. (fam. *Graminaceæ*)" (U. S. P.). Corn-silk should be collected soon after flowering, while still green and succulent, and preparations are believed to be better when made from it without previous drying. The important constituent is believed to be *maizenic acid*, which exists in the proportion of about two per cent. and is soluble in both water and alcohol. There are also fixed oil, resin, sugar, and gum. Of the physiological action of corn-silk, nothing is definitely known except that it is a direct stimulant of the renal secretion. With this action, it commonly produces a soothing effect when irritation of the genito-urinary tract exists. This appears to be due, at least in great part, to the cleansing effected. Its use is almost exactly like that of *Triticum* in cystitis. The official preparation is the fluid extract, of which the dose is 2 to 8 c.c (fl. ʒ i. to ij.). The decoction or infusion is perhaps more frequently employed.

Henry H. Rusby.

CORN-SMUT. See *Ustilago.*

CORNU CUTANEUM.—DERIVATION.—Lat. *cornu,* a horn.

SYNONYMS.—Cornu humanum; cutaneous horn; horny excrescence; horny tumor; Ger., *Hauthorn, Hornauswuchs;* Fr., *Corne de la peau.*

DEFINITION.—Cornu cutaneum is a true horny excrescence of the skin, varying in size and shape, and resembling in its general structure that of an animal.

SYMPTOMATOLOGY.—Horns are of rare occurrence, and their favorite location is upon the face and scalp, although they may occur on any part of the body. In Lebert's analysis of 109 cases they were distributed as follows: hairy scalp, 25; forehead, 11; temporal region, 4; face including eyelids, 19; upper extremities, 8; lower extremities, 11; trunk, 7; glans penis, 6; scrotum, 2. According to Lozes, of 68 cases 37 were females and 31 males, and the growths were situated as follows: head, 15; face, 8; lower extremities, 18; trunk, 8; glans, 3.

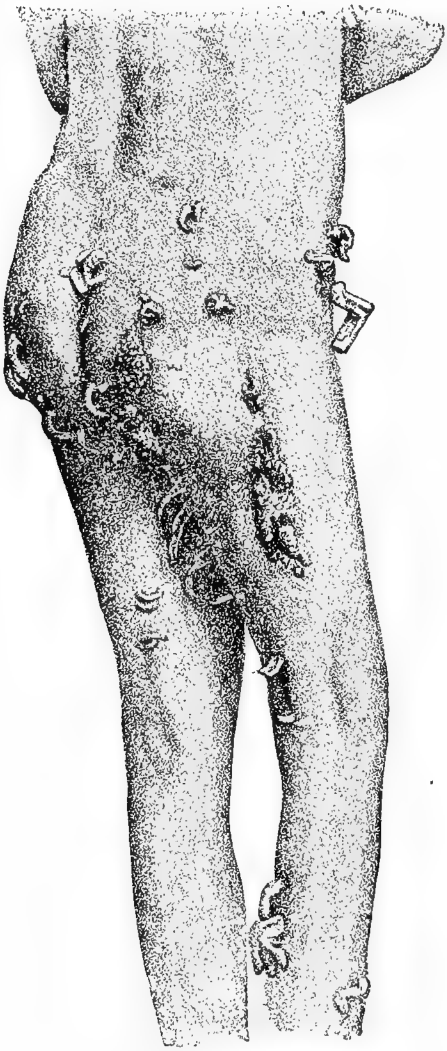

FIG. 1520. –Cornua Cutanea.

Among 90 cases of cornua cutanea (Wilson, Med. Chir. Trans., 1844, vol. xxvii., p. 52, and "Diseases of the Skin," sixth edition, p. 796) 44 occurred in women and 39 in men; they were located as follows: head, 48; face, 4; nose, 4; side, 11; leg and foot, 3; back, 6; glans, 5; trunk, 9. Although usually solitary, they may be multiple and at times quite numerous. Their size and shape differ, varying from a pinhead to several inches in length, and in some instances they have reached the length of twelve inches; their diameter varies from an eighth of an inch to from four to five inches. They are solid, dry, rough, wrinkled, or laminated on their surface and may be cylindrical, pointed, conical, straight, or twisted. The base exceeds the apex in breadth, is either concave or flattened, and is situated immediately upon or in a depression of the skin, which may be normal or more or less inflamed. Their color is usually gray, but variations from light yellow to dark yellow, brown, and sometimes black shades, are observed. Although bearing a close resemblance to animal horns, they differ anatomically from them in not containing bone. They grow slowly, as a rule, and are usually painless, unless subjected to rough use or irritation or are knocked off, when an ulcerating base comes to view, upon which a new horn is apt to be reproduced. After having attained a certain size they may grow loose and drop off.

ETIOLOGY.—We possess but little definite knowledge of the underlying causes. Horns are usually observed after middle life, although they may occur in very young individuals and are more frequent in females than in males. They usually originate from sebaceous cysts, sometimes from acuminated warts, and in some instances from cicatrices.

PATHOLOGY.—Horns are to be looked upon as acuminated warts and are due to cornification and hypertrophy of the epidermic cells; they commence in the rete mucosum. The papillæ are hypertrophied, and the horn is situated upon them. The base contains blood-vessels, which at times penetrate to some distance into the substance of the growth. Sometimes the base is situated in a follicle of the skin.

PROGNOSIS.—They rarely occur again after thorough removal; occasionally they undergo epitheliomatous degeneration.

TREATMENT.—The growth should be dissected out with care or torn or twisted off under anæsthesia, followed by thorough cauterization of the base with caustic potash, zinc chloride, or the curette or galvano-cautery may be employed. Complete removal of the base is necessary, for if this precaution is neglected the growth tends to recur. Early removal should be insisted upon in all cases, owing to the possibility of epithelioma taking place.

Emmanuel J. Stout.

CORONADO BEACH. See *California, Southern.*

CORONADO SPRINGS.—San Diego County, California. Hotel. These springs are located on and in the vicinity of Coronado Beach. They have an elevation of thirty feet above the ocean tide, and flow 50,000 gallons per hour. The water is clear and sparkling, and pleasant to the taste, being soft, pure, and wholesome. On analysis it was found by Mr. C. Gilbert Wheeler, analyst, to contain the following mineral ingredients:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	10.17
Potassium chloride	.91
Potassium sulphate	.55
Magnesium	4.73
Calcium carbonate	6.49
Calcium sulphate	1.33
Ferrous sesquioxide	.04
Silica	1.08
Organic matter	.99
Total solids	26.29

Gases not determined.

This water is found to compare favorably with that of the Bethesda Spring at Waukesha, Wis. That well-known water contains slightly more than twenty-five grains of solid matter to the United States gallon, many of the constituents being the same as those of the Coronado waters. These waters are gently aperient, diuretic, and tonic, and useful in dyspepsia, anæmia, renal and cystic disorders.

The accommodations at the Coronado Hotel are among the finest in the world. The building is a magnificent structure, and the scenery on the beach, on the shore of the Pacific Ocean, is never to be forgotten by one fortunate enough to behold it. (See also *California, Southern.*)

James K. Crook.

CORONER.—An officer existing among English-speaking nations, whose chief duty is the investigation of cases of violent, sudden, or suspicious death.

The early history of the coroner's office is involved in obscurity. Its origin has usually been attributed to the Saxon period of English history, but some of the ancient customs connected with it would seem to indicate an earlier origin. It is believed to have existed as early as the reign of King Alfred (871–900). Both this office and that of sheriff are apparently as old as the civil division known as the county, or shire. This arbitrary division, peculiar to English-speaking nations, was evidently of earlier date than the kingdom itself, the latter being composed by the aggregation of the former, which constituted petty kingdoms in themselves, the counties being made up of subdivisions (hundreds) of still earlier origin.

The name of the office was derived *a coronâ*, since the coroner was at first a royal officer. For many centuries county coroners have been elective officers. The right of the counties to elect their own coroners is confirmed by the Statute 3 Edward I., 10. Municipal boroughs also elect their own coroners. Certain franchises also have coroners of their own, within whose precincts the county coroner cannot act. In such places the coroner is appointed by the lord of the manor, and in one English franchise the coroner holds office by hereditary right. There are fifty-five franchise coroners, and one hundred and seventy-five coroners acting for counties, or parts of counties. These are very unequally distributed. Middlesex, with about four million inhabitants, including the populous part of London, has five coroners, while the small county of Huntingdon, with less than sixty thousand inhabitants, has also five, and Dorset, also a small county, has eleven.[1]

Every freeholder is entitled to vote in the election of coroner. No professional qualification is required for the office, the only requisite being that the candidate should possess a freehold interest in the county.

For more than fifty years complaints with reference to ignorance, and culpable neglect in the management of the office, have been so common as to direct popular attention to the necessity of reform; and while no comprehensive statute has been enacted with reference to such reform in England, the persistent efforts of prominent medical men have been so far successful that professional men are now usually elected to vacant offices.

The elections are often hotly contested, and as much as £12,000 is said to have been expended to secure an election. By a recent act it is provided that the polls shall not remain open more than one day.

A coroner usually holds office for life, but may be removed by the Lord Chancellor for misconduct or incompetence.

The county coroner receives a salary. He may appoint a deputy to act during his absence or illness. This deputy must be either a barrister, a solicitor, or a physician. The coroner is *ex-officio* a justice of the peace, and may therefore cause any one suspected of murder to be arrested, even before the jury has found its verdict.[1]

The office is regulated by common law, and also partly by fifty-five statutes, beginning with 1275 and ending with an act of 1897. The Consolidated Coroner Act of 1887 is an important act, since it embraces the amendments and modifications made in the English Inquest Laws up to that date.

The principal topics treated in this statute of 1887 are the inquest, the liabilities of the coroner, his appointment, qualifications, and fees, method of procedure at inquests, medical witnesses, and post-mortems, payment of fees and expenses, the coroner of the Queen's household, franchise coroners, definitions, etc. The fee of a medical witness for attendance at an inquest is one guinea, and for a post-mortem, including such attendance, two guineas. The coroner makes an annual return of his cases to the Secretary of State.[6]

Functions of the Coroner.—The powers of this magistrate were formerly much more comprehensive than at present. In addition to the duty of holding inquests upon the bodies of persons found dead from violent, sudden, suspicious, or unknown causes, he was also charged with the duty of inquiries concerning incendiary fires, shipwrecks, treasure trove upon land and sea, including whales and sturgeons cast upon the shore, and deodands.

Any personal chattel, animal, or thing, forfeited to the King for pious uses, on account of its having caused the death of a human being, was termed a deodand (*deo dandum*). Blackstone traces the custom back to Greek and Jewish laws, which required the destruction of anything which caused a man's death, the notion of the punishment of the animal or thing being implied. Certain peculiar distinctions existed in relation to deodands, as, for instance, between objects in motion and others standing still. If a horse or other animal in motion killed any one, either infant or adult, or if a cart ran over him, it was forfeited as a deodand. If death was caused by falling from a cart, or a horse at rest, the law made the chattel or animal a deodand, if the person killed were an adult, but not if he were a child. If death was caused by a thing not in motion, that part only which was the immediate cause of death was forfeited. If one be climbing upon the wheel of a cart, and is killed by falling off, the wheel only was a deodand. If the cart be in motion and run over some one, the whole cart and its burden also are forfeited. Similar distinctions prevailed with reference to vessels at anchor and under sail.[2]

The finding of a jury was necessary, not only to determine the facts, but also the value of the chattel which was thus decided to be a deodand. The nature and value of the weapon or chattel must be distinctly stated. This singular custom became deservedly unpopular, and juries interfered with the action of so unjust a measure until the act of 1846 (9 and 10 Victoria, c. 62) provided that there should be no forfeiture of any chattel for, or in respect of, the same having caused the death of a man; and no coroner's jury sworn to inquire, upon the sight of any dead body, how the deceased came to his death, shall find any forfeiture of any chattel which may have moved to, or caused the death of the deceased, or any deodand whatever; and it shall not be necessary, in any indictment or inquisition for homicide, to allege the value of the instrument which caused the death of the deceased, or to allege that the same was of no value.[2]

With the numerous accidents constantly occurring at the present day, on sea and on land, on railways, steamers, and other conveyances, such a law would be productive of great inconvenience and obstruction to public travel.[2]

Appeals of wounds, rape, and mayhem were also committed to the coroner. Many of these functions have become obsolete, and with the exception of his assumption of the powers of the sheriff, in the event of that officer's absence, or his inability to act in consequence of a criminal action against himself, the coroner's duty is mainly that of inquest upon the bodies of persons found dead. In England at the present day this duty is limited to cases of death by violence, deaths of persons in prison, and deaths by sudden or unknown causes. It is also customary to hold an inquisition in the case of a suicide or *felo-de-se*.

The term *felo-de-se* is nearly synonymous with suicide. It has, however, occasionally a more restricted signification, when applied to "any one who commits an unlawful malicious act, the consequence of which is his own death, as if, attempting to kill another, he runs upon his antagonist's sword, or shooting at another, the gun bursts and kills himself." For many centuries it was the custom in England to bury each *felo-de-se* on the highway with a stake driven through the body. This ignominious form of burial was abolished in the reign of George IV., by an act of Parliament which ordered the burial of the body of a *felo-de-se* within twenty-four hours after inquest, between the hours of nine and twelve at night, and without the rites of Christian burial[2] (Act of 4 George IV., 1823).

An inquest must be held with, or in presence of, a jury consisting of twelve men. It must also be held *super visum corporis;* that is to say, the body must be seen both by the coroner and by the jury. The jury is sworn by the coroner, and is then charged to inquire how the deceased came by his death. Witnesses are also examined under oath, and the coroner has power to order an autopsy, and the attendance of medical witnesses. The finding of the jury (verdict) is recorded on parchment, and is attested by the signature and seals of the jury and of the coroner. If, on such finding, any one is found guilty of murder or manslaughter, the coroner commits him to trial, and the accused may be indicted on the inquisition without any presentation before the grand jury. Practically, an independent inquiry is always held before a justice in the ordinary way.[1]

Other Modes of Inquiry.—Neither the coroner nor his jury exists among the continental nations of Europe, and the modes of procedure in the case of bodies found dead by violence or unknown causes, in all continental countries, and in Scotland, agree in the absence of these officials.

In France the investigation is conducted by two officers, whose functions are entirely distinct, a legal and a medical officer. The former, the *procureur de la république*, an officer somewhat analogous to the district attorney, takes the initiative in each case, proceeds to view the dead body, summons witnesses, and takes the evidence. Liberal power is granted to him, and he can seize articles, or papers, connected with any crime, restrain persons from leaving the premises, and employ experts and detectives, as the case may require. In the latter direction the French system is, beyond question, an unusually efficient mode of procedure.

The other officer, the medical, is selected for his superior training and knowledge, and has charge of the medical examination of the body. Sometimes two medical officers are employed. The medical officer is also still further associated with the subsequent prosecution of suspected parties, when the legal officer has decided that a crime has been committed. His report must be signed by a police official and submitted to a magistrate. If the evidence presented to the magistrate is deemed sufficient, an indictment is prepared for the *cour d'appel*, and a trial may then take place before a jury.[3]

In Scotland the process employed is similar to that of France. The procurator fiscal, who has the investigation in charge, has for his guidance a code of instructions drawn up by the lord advocate. This code also gives detailed directions to the medical men who have the charge of the medical examinations, two medical officers being employed in each case. The reports of these officials are sent to the office of the crown agent at Edinburgh, and by him are transmitted to the advocate deputé. If he decides that there is suspicion of crime, he refers the report back to the procurator fiscal for further investigation. If he is in doubt, he may bring the case before the crown officers. Beyond this, a criminal trial is much the same as in England.[4]

In Germany there is neither coroner nor any analogous officer, nor a jury, on the preliminary investigation. A judicial officer has charge of the proceedings (Staatsanwalt). His powers are like those of a district attorney. The police are under his control in all matters relating to the investigation of crime. They are also bound on their own part to investigate suspected crimes, cases of sudden or violent death; and no interment is allowed in such cases till after the consent of the district attorney or a competent court is obtained. Medical officers are regularly appointed to make autopsies and medical examinations and report upon them. The German code of regulations as to the modes of procedure in examinations of bodies, both judicial and medical, is very explicit. If the district attorney believes that a crime has been committed, he institutes a trial, and if the court believes that sufficient reasons are presented, it orders a preliminary inquiry (gerichtliche Voruntersuchung) before a justice, the result of which is usually decisive. (Law of October 1st, 1879.)

In Russia the law is similar in its provisions to that of France.

In Denmark the system is also very efficient, a judicial officer being appointed who has charge of all cases, which he decides without the intervention of a jury. He refers all medical questions to a medical officer who is appointed for the purpose, and reports to the judge the result of his examination, and autopsy, if one is made. He also makes a similar report to the Royal Bureau of Health. The trial which follows, in case of indictment, is first before the county judge, from whom appeals may be made to higher courts.[3]

United States.—The laws relating to inquests in the United States all bear the marks of English origin, and were evidently introduced by the early settlers, with most of the peculiarities of the English law, though stripped of some of the singular customs of early times. The coroner, the coroner's jury, and the inquest, exist in nearly all of the United States, at the present time, practically in the English form. Massachusetts made a radical change, abolishing the office of coroner, and also the jury, in 1877, since which time inquests have been conducted with greater care and economy, and to the entire satisfaction of the people and of the State (see *Examiner, Medical*).

Connecticut and Rhode Island have also recently enacted similar laws, of a less radical nature.

In the other States there are certain points of difference, chiefly of minor importance, relating to the functions of the office of coroner, the mode of his election or appointment, his fees, the number of the jury, and the employment of medical officers.

Some of the singular provisions of the English law relative to the vicarious duties of the coroner were introduced into the early colonial statute-books, and are still retained in nearly every State of the Union. Instances, however, in which the coroner officiates as a sheriff are of rare occurrence.

The chief function of the coroner in all of the United States, as in England, is the holding of inquests upon the bodies of persons found dead, from either violent, or suspicious, or unknown causes; and while there is considerable variability in the definition of this function by the statutes of different States, the intent or spirit of the law is evidently similar in all. In Massachusetts, under the old law, the coroner was authorized to hold inquests on the bodies of such persons only as were "supposed to have come to their death by violence," a special provision requiring an inquest in every case of death by railroad accident.

In California, and in several other States, it is specified that inquests may be held upon the body of "any person who has been killed, or has committed suicide, or has suddenly died under such circumstances as to afford a reasonable ground to suspect that the death has been occasioned by the act of another by criminal means."

In a few States an inquest may be held in the case of a person who is seriously wounded, and in imminent danger of death. In Indiana, the jury was abolished by an act of 1879. In Texas, the inquest is also held without a jury.

In Alabama, in addition to the usual duties, it is required that the coroner shall be keeper of the jail when the sheriff is imprisoned, and when the coroner is imprisoned a special coroner may be appointed. He also performs the duty of sheriff when required, as provided under the English law.

In Kentucky inquests may be held in cases of housebreaking. In several of the Southern States the coroner is a conservator of the peace, and is required to suppress riots and disturbances, and may apprehend and commit felons and traitors. In Mississippi the coroner is also the county ranger, and performs the duties of that office. (It is the duty of the county ranger to take charge of stray horses, mules, jacks, cattle, sheep, or hogs.)

The modes of election in the different States are quite diverse. In Alabama, Arkansas, Colorado, Georgia, Idaho, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Nebraska, Nevada, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Washington, Wisconsin, and Wyoming, the coroner is elected by the inhabitants of the county. In Tennessee he is appointed by the county court. In Virginia a county court appoints a coroner for two years, and can appoint more if necessary. In Illinois, Indiana, Maine, and New Hampshire the governor appoints the coroner. In Texas, Vermont, and Utah, the office of coroner is unknown, a justice of peace acting in all cases in which the presence of such an official is required.[5, 7]

The fees of coroners are also varied. In New Hampshire the fee for holding an inquest is $1.50. In some States it is $5, in others $10. The fees for recording, for mileage, and other items also present a wide range of variation. In some States, by recent statutes, stenographers may be employed at inquests, payable either by a monthly salary as in Kentucky, or by stipulated fees for work performed.

In some States physicians are regularly appointed to perform the necessary examinations for coroners. In others the coroner selects any physician whom he may choose for each case requiring such assistance. The compensation of physicians thus employed ranges from $6 in Minnesota, to $50 in other States, for an autopsy, and $100 in Mississippi, in cases where the body is exhumed.[5] In Missouri the fee for a post-mortem is $10, but if the coroner makes it himself it is $25. In New Jersey the coroner may provide grave-clothes to the amount of $1 each for nude bodies.

In several cities of the United States, the coroner is a salaried officer, such being the case in New York, Philadelphia, Detroit, St. Louis, Cincinnati, Cleveland, Washington, Charleston, Wilmington (Del.), and other cities, a plan which has obvious advantages.

The requisite number of jurors is usually either six or twelve. In New Hampshire it is limited to three, in Louisiana five, and seven in Tennessee. In several States it is required that a larger number of jurors be summoned than is needed to be sworn for the inquest, the number thus summoned ranging from nine to twenty-three.

The amount of the bond required of a coroner varies from as low as $250 in Colorado to $50,000 in the larger cities of Ohio.

The jury is usually selected from the inhabitants of the town or county. In Iowa, North and South Dakota, from the "electors." In Kentucky they must be "housekeepers." In Utah they must be "qualified residents." In Washington a jurist must be a "male inhabitant" over twenty-one years old, and of sound mind. In West Virginia he must be a "suitable resident."

In Washington a jury is thus defined: "A jury of inquest is a body of men, six in number, summoned from the qualified inhabitants of a particular district, before the coroner, or other ministerial officer, to inquire of particular facts."

In Wisconsin the coroner is *ex-officio* a deputy fish and game warden, and must assist the State warden upon due notice. He must resign to the sheriff, who transmits his resignation to the governor. The coroner must also make complaint as to violation of statutes relative to sale of liquor to Indians.

In Colorado the coroner may be tried for bribery and for assault. He cannot practice as an attorney. He must investigate mining accidents. He must seize gambling inplements, take snares, traps, nets, etc., and is liable to many penalties.[7]

(See also *Cadaver, Legal Status of*, and *Examiner, Medical.*)

Samuel W. Abbott.

[1] Chalmers, M.D.: Local Government, London, 1883.

[2] Encyclopedia Britannica, ninth edition, vols. vi., vii., and ix. Articles Coroner, Deodand, and Felo-de-se.

[3] Bell, Clark: Bulletin of the Medico-Legal Society of New York, January, 1881. Art., the Coroner's Office.

[4] Maclagan, Douglas, M.D., F.R.S.E.: Forensic Medicine from a Scottish Point of View, Edinburgh, 1879.

[5] Lee, John G., M.D.: Handbook for Coroners, Philadelphia, 1881.

[6] The Coroners Act, 1887, 50 and 51 Victoria, Chap. 71, English Statutes.

[7] Recent statutes of the different States of the Union (1890–98).

CORONILLA.—A genus (fam. *Leguminosæ*) of some twenty species, of Europe, Northern Africa, and Western Asia, some cultivated for ornament. Several of these, notably *C. scorpioides* (Medic) Koch, act powerfully upon the heart, stimulating it and, apparently through increased blood pressure, producing marked diuresis. These properties reside in the glucoside *Coronillin* ($C_7H_{12}O_5$), a yellowish powder, soluble in both water and alcohol. It possesses the same properties as the drug, which are almost identical with those of digitalis, and it is indicated and contraindicated like that drug. Coronillin has been given in doses of 0.1 to 0.15 gm. (gr. iss. to iij.) five or six times in the twenty-four hours.

Henry H. Rusby.

CORPORA AMYLACEA.—These bodies are small, round, homogeneous, or concentrically stratified concretions occurring most frequently in the prostate, nervous system, and lung. Their concentric stratification resembles very much that of starch grains, and this with the fact that with iodine, or with iodine and sulphuric acid, they frequently take on the characteristic blue color has led to their name and to their being classed with amyloid. It is, however, evident that they have an entirely different significance from that of the progressive amyloid change beginning in the walls of blood-vessels, and they should be regarded as being of different pathological origin and nature.

While these bodies frequently assume with iodine and sulphuric acid colors varying from blue, brownish red, and green to yellow, it is stated that they but rarely give the amyloid reactions with the aniline dyes, and then only to a slight degree, usually in the central portion of the concretion. The writer has been unable to obtain any reaction from these bodies with the aniline dyes which he regarded as characteristic of amyloid, and it is his opinion that they should be classed with the colloid or colloid-like bodies rather than with amyloid. In the majority of cases these concretions react to stains in a manner similar to that of colloid. With Weigert's fibrin stain they take a deep violet color. They are essentially a local product dependent upon local conditions, and are for the greater part derived from epithelial cells and represent a transformed gland secretion. In this respect their origin is the same as that of epithelial colloid. In the nervous system they arise from degeneration of either the neuroglia cells or the axis cylinders, and the chemical nature of the concretions found in the brain and spinal cord must be different from that of those formed in the prostate and lungs. This is further shown by difference in appearances, staining reaction, etc., exhibited by the concretions found in these different regions.

In the prostate the bodies lie in the lumina of the gland spaces. They vary in size from a leucocyte to large concretions visible to the naked eye. They may be so numerous as to give the cut surface of the organ a brown, granular appearance. The free concretions may be obtained for examination by scrapings taken from the cut surface of the organ and examined upon the slide. Pressure upon the cover glass produces numerous radiating fissures in the firm bodies. In unstained sections these concretions may appear colorless, brown, dark brown, or yellow, and the striations may show more or less distinctly. In sections from hardened material the majority of the bodies are torn out by the microtome knife, or drop out in the handling of the section. Their consistence becomes very firm, especially in material embedded in paraffin, so that they not infrequently turn the edges of the knife. In this respect they resemble the colloid of the thyroid. In stained preparations the concretions may show a great variety of forms and colors. The gland spaces may be filled with large and small bodies; or concretions of different size, shape, and color may be conglomerated together by a lighter hyaline substance. The darker prostatic concretions show most frequently a concentric or radiating striation. The central portion of the body may consist of a hyaline nucleus, or the periphery may be light-colored and hyaline. Frequently the peripheral zone of the concretion is darker and firmer in consistence than the central portion. The larger concretions may show alternating zones of light and dark colors, or may be made up of conglomerated granules of different shades of color. Deposits of lime salts and blood pigment are not infrequently found in the older brown bodies. As a rule, the number of the prostatic concretions is greatest in old age, but they also occur in the prostates of newly born infants. Moreover, they are not a constant accompaniment of senility, and their exact physiological or pathological significance is as yet unknown. They must be regarded as the product of degenerated epithelium or transformed prostatic secretion.

The corpora amylacea of the nervous system are found most abundantly in the ependyma of the ventricles, in sclerotic areas of the brain and cord, and in atrophic nerves. They are especially common in the areas of degeneration in tabes dorsalis, and are also of frequent occurrence in the senile atrophy of nervous structures. They differ in many respects from the concretions of the prostate and lung, being, as a rule, much smaller than the latter, though many times larger than the nuclei of the neuroglia cells. They are usually homogeneous, and only rarely show faint striations. They are round or oval in form, possess no definite nucleus, and are sharply outlined peripherally. They stain very deeply with hæmatoxylin, and for this reason have been thought to be formed from degeneration products of the nuclei of the glia cells. By some writers they are regarded as myelin products arising from the degeneration of nerve fibres. Others consider them to be derived from changed albuminous constituents arising from the cells.

Corpora amylacea are found in the lungs under many varying conditions: in acute and chronic pneumonias, in emphysema, in hemorrhagic infarction, in the neighborhood of tumor nodules, in tuberculous areas, and in the alveoli near the inflamed pleura. The writer has also observed them in lungs showing no pathological changes. In pneumonia they are frequently found embedded in masses of cellular and fibrinous exudate. They appear as round or oval homogeneous bodies, the larger ones frequently showing striation. In the central portion of the body degenerated cells, particles of carbon, blood pigment, etc., are often found, forming a nucleus around which the deposit of the concretion has taken place, through the precipitation of albuminous exudate or the accumulation of the products of degeneration of epithelial cells. In so far as the writer's experience goes, the corpora amylacea of the lung never give an amyloid reaction with the aniline dyes. With other stains they react similarly to the concretions of the prostate.

Corpora amylacea have also been observed in carcinomata, in inflammatory areas, in old extravasations, and in the glands about the beginning of the urethra in the female. The writer has also seen them in tumors of the parotid and mammary glands, in cysts of the ovary and kidneys, in the seminal vesicles, vas deferens, and epididymis, and in the small closed gland spaces near the prostate which are probably vestiges of the ducts of Müller. In all of these cases the origin of the concretions is apparently the same; the bodies represent transformed albuminous constituents of epithelial secretions. *Aldred Scott Warthin.*

CORYZA. See *Nasal Cavities, etc.*

COSAPRIN.—$C_6H_4,NHCO,CH_3,SO_3Na$. This is a whitish, crystalline mass or fine powder obtained by acting upon sodium sulphanilate with acetic anhydride. Its taste is slightly salty; it is freely soluble in water, slightly so in alcohol, and almost insoluble in ether. Its solutions have a weak alkaline reaction, and it is decomposed by heating with acids. Vámossy and Fenyvessy find that it is strongly antipyretic like phenacetin, but its action is more prompt and less lasting. *W. A. Bastedo.*

COTO.—The bark of an unknown Bolivian tree of the family *Lauraceæ.* The writer of this article is probably the only botanist who has seen a botanical specimen from this tree. It was furnished him in La Paz, coming from the Indians of the lower La Paz River region, and consisted of a twig with several thick, coriaceous, lanceoblong leaves nearly a foot in length, and a fruit like a large acorn. It was evidently a species of Nectandra or of a closely allied genus. The specimen was forwarded but disappeared in transit.

The bark first appeared in market confounded with cinchona, but later with individual claims. It occurs in good-sized flattish pieces, four to twenty inches long by five to ten in width and one to two or three in thickness. It is of a deep red-brown color throughout, often with a violet or purple tinge to the brown. If, as is usual, the entire thickness is present, the outer surface is grayish, and little furrowed and fissured. The inner surface is very roughly striated or splintered, like the ends. The outer third is cellular, the remainder a mass of splintery bast tissue. The bark is very hard and heavy. It has a camphoraceous, aromatic odor, and two distinct elements are recognizable in the taste. It is immediately pungent, and very quickly peppery-biting in addition (see *Coto, Para*).

Its volatile oil, resin, and *piperonylic acid* ($C_6H_3[O_2CH_2]COOH$) are all active, but the *cotoin* ($C_{22}H_{18}O_6$), which occurs as a yellow, crystalline powder, soluble in alcohol and slightly in water, is regarded as the important constituent and has been used alone. Tannin is not present.

In its own home, Coto possesses the highest reputation as a remedy, not only for diarrhœa, but for dysentery, which is there one of the commonest and most fatal of diseases. It is an excellent stomachic and a very powerful intestinal stimulant, especially to the sympathetic system and to the functions of absorption, at the same time exerting a disinfectant action. It is of great value in controlling intestinal discharges. The fluid extract is the best preparation, the dose being 0.3 to 1.5 c.c. (♏ v. to xx.). The powdered bark is very effective in equivalent doses. Cotoin is given in doses of 0.03 to 0.2 gm. (gr. ss. to iij.). *Henry H. Rusby.*

COTO, PARA, or Para Coto, is the bark of a tree apparently very closely related to the last and comes from the same locality. The bark is very similar in appearance, but is commonly a half thicker and in larger pieces, their curvature greater. It is more commonly deprived of the outer bark. When this is present it is rougher and browner. The best distinction is in the taste, which has a similar prompt pungency, but lacks the secondary peppery-biting element. It contains, in addition to the constituents of the last other than cotoin, *paracotoin* ($C_{19}H_{12}O_6$), which is yellow, crystalline, soluble in both water and alcohol, and acts similarly, but two or three times weaker; also *protocotoin* ($C_{16}H_{14}O_6$), yellow and crystalline, soluble in alcohol.

This bark acts similarly to the last, but is much weaker. It is also much cheaper, and is very generally supplied in the United States when coto is called for.

Henry H. Rusby.

COTTON.—The plant *Gossypium herbaceum* L. and other species of *Gossypium* (fam. *Malvaceæ*). It yields to the materia medica, besides various fabrics of use in surgery, the following articles, which will be considered in order: cotton-root bark, cotton-seed oil, absorbent cotton, pyroxylin, collodion.

The specific identity and nativity of the different cotton plants are still subjects of controversy. Apparently some are of Asiatic, others of tropical American origin. As they agree in their properties, these questions are not here of practical importance. The plants are either herbs or shrubs, some reaching the dimensions of small trees, though the *tree cottons* proper of tropical America do not belong to this group at all. The cottons have alternate, stipulate, coarsely toothed or lobed leaves, and handsome large hollyhock-like flowers, white or yellow or changing with age to rose color. The fruit ("boll") is a large, ovoid capsule, bursting at maturity into three or four lobes. The seeds are numerous, white, dark brown, or black, and completely concealed in the cotton-fibre, which consists of long white or tawny hairs developed from the seed coat. The plant abounds in mucilage, and its herbage and flowers have some domestic use for poultices, and the juice, as well as a decoction of its leaves, internally, as a demulcent.

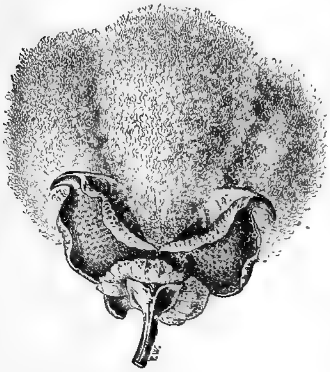

FIG. 1521.—Cotton Boll, one-half natural size. (Baillon.)

COTTON-ROOT BARK. GOSSYPII RADICIS CORTEX.—"The bark of the root of *Gossypium herbaceum* L. and of other species of Gossypium" (U. S. P.). There are few official drugs so much in need of pharmacological study as this. There is the widest variation in the activity of different samples, apparently genuine, but of the causes of this variation we are ignorant. It has been claimed that the bark should be extracted in the recent state, also that the bark of the stem is frequently furnished instead of that of the root. It is by no means impossible that the age of the plant when the bark is collected, or its previous destruction by frost, affects its quality. Finally, it would seem that the bark of the shrubby tropical forms might be more active than that of our annual plant. The bark is thus described in the Pharmacopœia:

"In thin, flexible bands or quilled pieces; outer surface brownish yellow, with slight, longitudinal ridges or meshes, small, black, circular dots, or short, transverse lines, and dull, brownish-orange patches, from the abrasion of the thin cork; inner surface whitish, of a silky lustre, finely striate; bast fibres long, tough, and separable into papery layers; inodorous; taste very slightly acrid and faintly astringent."

The drug contains fat, resin, red coloring matter, and a small amount of tannin.

Our first knowledge of its properties came from its use among the negroes of the Southern United States for the production of criminal abortion. Speculation as to the source of their knowledge, and of its introduction from Africa, raises important questions as to what species may have been there employed. Our slight knowledge of the drug's action is entirely clinical, and most of the testimony is against its activity, yet there is sufficient evidence that in some form it has been active as an abortifacient, parturifacient, and emmenagogue, acting much like ergot. The fluid extract is official, and the dose is 2 to 8 c.c. (ʒ ss. to ij.).

COTTON-SEED OIL. OLEUM GOSSYPII SEMINIS.—"A fixed oil expressed from the seeds of *Gossypium herbaceum* L. and of other species of *Gossypium*, and subsequently purified" (U. S. P.). The seeds are decorticated and lightly cooked before expression. The cake which remains is a most valuable fodder. The crude oil is largely used in the mechanical arts and for soap-making; but for domestic and pharmaceutical purposes it is purified by decantation after standing, boiling with water, and treatment with a weak alkali. The official oil is thus described:

"A pale yellow, oily liquid, without odor, and having a bland, nut-like taste.

"Specific gravity, 0.920 to 0.930 at 15° C. (59° F.).

"Very sparingly soluble in alcohol, but readily soluble in ether, chloroform, or carbon disulphide.

"On cooling the oil to a temperature below 12° C. (53.6° F.), particles of solid fat will separate. At about 0° to −5° C. (32° to 23° F)., the oil solidifies.

"When the oil is brought in contact with concentrated sulphuric acid, a dark reddish-brown color is instantly produced.

"If 6 gm. of the oil be thoroughly shaken, in a test tube, for about two minutes, with a mixture of 1.5 gm. of nitric acid and 0.5 gm. of water, then heated in a bath of boiling water for not more than fifteen minutes, the oil will assume an orange or reddish-brown color, and, after standing for twelve hours at the ordinary temperature, will form a semi-solid mass.

"If 5 c.c. of the oil be thoroughly shaken, in a test tube, with 5 c.c. of an alcoholic solution of silver nitrate (made by dissolving 0.1 gm. of silver nitrate in 10 c.c. of deodorized alcohol and adding 2 drops of nitric acid), and the mixture heated for about five minutes in a water bath, the oil will assume a red or reddish-brown color."

Cotton-seed oil consists of olein and palmatin. It is quite devoid of medicinal properties. If thoroughly purified, it is an excellent and delicious article of food, scarcely distinguishable by the average palate from olive oil, for the adulteration and substitution of which it is very largely employed. It in turn is adulterated with maize oil. It is also very largely used for the adulteration of lard. In the pharmacy it has many uses in taking the place of other more expensive and not superior oils.

COTTON, ABSORBENT. PURIFIED COTTON. GOSSYPIUM PURIFICATUM.—"The hairs of the seeds of *Gossypium herbaceum* L. and of other species of *Gossypium*, freed from impurities and deprived of fatty matter" (U. S. P.). The cotton fibre is separated from the seeds, to which it is firmly adherent, by means of machines called gins, which, either by a series of circular saws revolving between the teeth of a comb-like guard or by cylinders which catch the cotton between them, pull or tear it away from them. It is then compressed in large bales and so exported. It consists entirely of long, thick-walled, collapsed, and spirally twisted tubes of glistening clearness, and high refractory power as seen under the microscope. It is nearly pure cellulose, with one or two per cent. of mineral matter, and has also a small amount of oily and resinous substances upon its surface—enough to make it repellent to water. For medical and surgical uses it is now beautifully purified from most of these impurities, and consists of more than ninety-nine per cent. of pure cellulose, $C_6H_{10}O_5$. The official purified cotton is thus characterized:

"White, soft, fine filaments, appearing under the microscope as hollow, flattened, and twisted bands, spirally striate, and slightly thickened at the edges; inodorous and tasteless; insoluble in ordinary solvents, but soluble in copper ammonium sulphate solution.

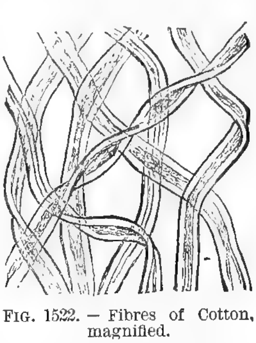

FIG. 1522. — Fibres of Cotton, magnified.

"Purified cotton should be perfectly free from all visible impurities, and, on combustion, should not leave more than 0.8 per cent. of ash.

"When purified cotton, previously compressed in the hand, is thus thrown on the surface of cold water, it should readily absorb the latter and sink, and the water should not acquire either an acid or an alkaline reaction (evidence of proper purification)."

Purified cotton is daily employed by the apothecary as a rapid filter or strainer for turbid solutions; it is also employed in the laboratory of the bacteriologist as a stopper for the tubes in which his "cultures" are made; but for this purpose it has to be specially "sterilized" by heat or other means. It is also used in the preparation of the aromatic "*Aquæ*" to distribute the essential oils over, in order to insure their most complete solution. It is also very extensively used, either with or without medication, as a surgical dressing. Dried from a solution of boric acid, 1 to 100; corrosive sublimate, 1 to 1,000; or carbolic acid, 1 to 20; or impregnated with powdered iodoform, it can be rendered antiseptic; but such preparations need to be recently made, especially that with the carbolic acid. Exposure to a heat of something more than 100° C. (212° F.), for say half an hour, renders it practically aseptic, and in this condition it is very largely used as a dressing in antiseptic surgery. Nearly all surgical bandages, compresses, and gauze materials in this country are made from cotton.

The only preparation of purified cotton is the following, with its preparation, collodion:

COTTON, GUN, or GUN COTTON; SOLUBLE GUN COTTON; PYROXYLINUM; PYROXYLIN; COLLOXYLIN; DINITRO-CELLULOSE (U. S. P.). The following is the official formula and method of preparation:

℞ Purified cotton	100 gm.
Nitric acid	1,400 c.c.
Sulphuric acid	2,200 "
Alcohol,	
Ether,	
Water	āā q.s.

Mix the acids gradually in a glass or porcelain vessel, and, when the temperature of the mixture has fallen to 32° C. (90° F.), add the purified cotton. By means of a glass rod imbue it thoroughly with the acids, and allow it to macerate, until a sample of it, taken out, thoroughly washed with a large quantity of water and subsequently with alcohol, and pressed, is found to be soluble in a mixture of *one* (1) *volume* of alcohol and *three* (3) *volumes* of ether. Then remove the cotton from the acids, transfer it to a larger vessel, and wash it, first with cold water, until the washings cease to have an acid taste, and then with boiling water, until they cease to redden blue litmus paper. Finally, drain the pyroxylin on filtering paper, and dry it in small, detached pellets, by means of a water bath or steam bath, at a temperature not exceeding 60° C. (140° F.).

Keep the pyroxylin, loosely packed, in well-closed vessels containing not more than about 25 gm., in a cool and dry place, remote from lights or fire.

Pyroxylin owes all its usefulness in medicine to the fact that it can be dissolved by a mixture of alcohol and ether, and forms with it an adhesive varnish which dries to a waterproof film or coating, that can be made to cover and protect or hold injured surfaces, or be used as a vehicle for certain medicaments. The following is the formula for collodion (*Collodium*, U. S. P.):

Pyroxylin	30 gm.
Ether	750 c.c.
Alcohol	250 "

Dissolve and decant.

The film produced by this collodion as it dries contracts with considerable force, and is sometimes useful where a local compression is desirable; but for most purposes this quality is an objection, and it is partially overcome in the next preparation, flexible collodion (*Collodium Flexile*, U. S. P.):

Collodion	92 parts.
Canada turpentine	5 "
Castor oil	3 "

Styptic Collodion (*Collodium Stypticum*, U. S. P.), is a preparation of collodion, alcohol, and ether, containing twenty per cent. of tannic acid.

Cantharidal Collodion or *Blistering Collodion* (*Collodium Cantharidatum*, U. S. P.) is a preparation of collodion containing the active constituent of 60 gm. of cantharides, extracted by chloroform, for every 100 gm. of the preparation.

Henry H. Rusby.

COUCH GRASS.—TRITICUM. *Dog-grass.* "The rhizome of *Agropyrum repens* (L.) Beauv. (fam. *Gramineæ*), collected in the spring and deprived of its roots" (U. S. P.) It is a perennial grass with a straggling, zigzag stem, and a two-rowed ear of pointed spikelets. It spreads principally by means of long subterranean, horizontal rhizomes of most remarkable vitality and persistence of growth. Introduced from Europe and Asia, it has become a troublesome weed in some parts of this country. The drug comes principally from Germany. The dried rhizome is generally cut in short pieces (1 cm. or so long), about 2 mm. in diameter. It is hollow excepting at the joints, dull-yellow, and odorless, or having a slight mixed smell of hay and earth; taste sweetish, not remarkable. There is nothing notable in its composition or medical qualities, still it has some reputation in chronic inflammation of the bladder and kindred disorders. It is a favorite article for preparing patients for operations for cystic calculi. It contains sugar, gum, and *triticin*, which is very similar to inulin. We have an official fluid extract, dose 2 to 8 c.c. (fl. ʒ ss. to ij.), and it is commonly given in decoction.

Henry H. Rusby.

COUGHING.—According to Webster, the English word cough (Lat., *tussis;* Fr., *la toux;* Ger., *der Husten*) is of Anglo-Saxon origin, and comes from the Dutch, *Kuch*—M. H. Ger., *kuchen*, to breathe; N. H. Ger., *keuchen*—whence the German term, *Keuchhusten*, for whooping-cough.

Cough is primarily a physiological act, protective in character. Under pathological circumstances it occurs as a symptom of local or general morbid conditions, and may be of mechanical or reflex origin. It is essentially a quick and forcible expiratory effort or series of such efforts, performed with complete or partial closure of the glottis, and is usually preceded by one or more deep inspirations. It has for its object the removal from the air

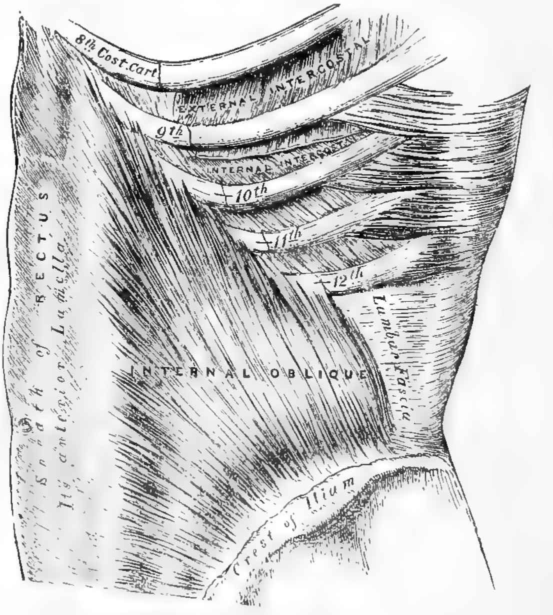

FIG. 1523.—Attachments of Rectus and Internal Oblique Muscles.

passages of obstructive or irritating materials. It may be excited by irritation of the nerves when there is nothing to be extruded, and is most annoying and persistent under such circumstances. Its mechanism is thus described by Westbrook in the first edition of this Handbook.

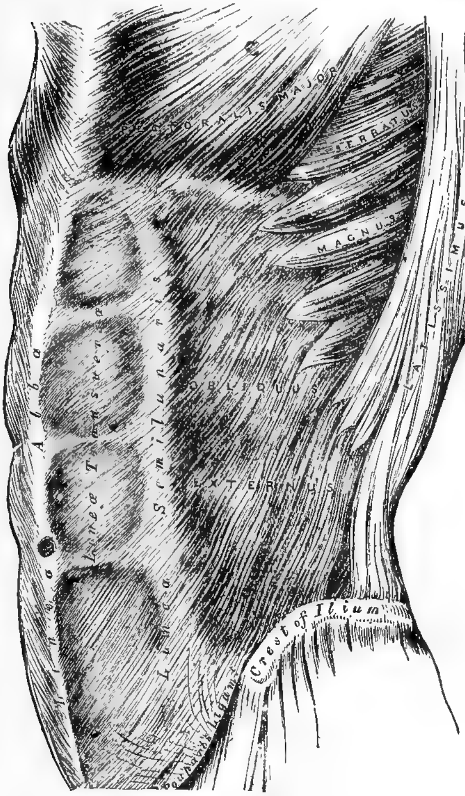

FIG. 1524.—Attachments of Rectus and Lateral Oblique Muscles.

"The *mechanism* of cough is as follows: When a foreign body or other irritant comes in contact with the peripheral expansion of the pneumogastric nerve (or of those with which it is intimately connected), impulses are generated which, travelling along the afferent fibres, are conducted to the respiratory centre in the medulla oblongata. In the ganglion cells of this centre the impulses are translated into others, which are conducted through the efferent fibres of certain cerebral and spinal nerves to the muscles of respiration, whose force they liberate.

"A study of the muscular relations of the thoracic walls shows that, while the muscles of *inspiration*—with the exception of the diaphragm and some small ones, *e.g.*, the *levatores costarum*—are attached to, and act upon the upper ribs, the *expiratory* group make their principal traction upon the lower portions of the thorax. This is particularly the case with those auxiliary muscles which are brought into play in forced respiration. The expiratory group, in which we are especially interested, are, anteriorly and laterally, the *triangulares sterni* above, and the *recti*, *obliqui*, and *transversales abdominis* below.

"The action of the *triangularis* is simple, and does not require special notice. Arising from the sternum and xiphoid appendix, its fibres pass upward and outward, to be inserted into three or four of the costal cartilages. It reinforces the natural resilience of the cartilages, helping to restore them to the expiratory position. It may also have some effect in counteracting the displacing force of the muscles on the exterior of the chest, *e.g.*, the *pectoralis minor*. The action of the *rectus* is equally simple. Its sole influence over the respiratory movements is to draw the sternum downward, and so to diminish the size of the anterior wall of the abdominal cavity. The action of the *obliqui* is more complicated. In the first place their posterior portions, which pass directly from the crest of the ilium to the ribs, exert an immediate and powerful downward traction upon the thoracic walls, not only diminishing the size of the lateral walls of the abdomen, but acting as *adductors* to the ribs, which have been put in the position of *abduction* during inspiration. In the second place, the more anterior portions have a crossed action, and make diagonal traction across the abdomen. This has been well described by Henle. It will be seen by reference to Figs. 1523 and 1524 that the upper portion of the *external*, and the middle portion of the *internal oblique* muscles of opposite sides, attached, as they both are, to the intervening sheath of the *rectus*, are equivalent to one long diagonal muscle, which passes from the ribs on one side to the iliac crest on the other, and is capable, by its contraction, of drawing the ribs downward and inward, so as to contribute much toward the expiratory diminution of the thoracic cavity. It acts upon the abdomen as well. The function of the *transversalis* is equally important. Its middle portion is attached by a strong fascia to the transverse processes of the lumbar vertebræ; while the fibres below arise from the iliac crest and outer half of Poupart's ligament. Above, it arises from the inner surfaces of the costal cartilages.

"The fibres of this part of the muscle pass horizontally across the abdomen, and, by the mutual attachment of those from the opposite sides at the *linea alba*, one continuous muscle is formed, the contractions of which strongly adduct the lower costal cartilages and thus diminish the epigastric angle. The middle portion of the *transversalis* acts directly upon the abdominal wall. This is best illustrated in a horizontal section of the trunk just above the level of the umbilicus (see Fig. 1525).

"In its contraction the *transversalis* acts from the outer border of the *quadratus lumborum*, as that muscle fixes its tendon in the lumbar region. It tends, first, to draw the *linea alba* toward the fixed point; but the antagonism of the muscles of the opposite sides prevents lateral displacement, and simply allows the anterior abdominal wall to approach the vertebral bodies, shortening the antero-posterior diameter. The muscular fibres intermediate between the anterior and posterior attachments, which, during distention of the abdomen, are sharply curved, become straightened during contraction and make strong lateral compression.

"The lower fibres of this muscle, when they contract, tighten the line across the inferior abdominal regions, and compress the intestines. The *transversalis*, then, by its contraction, first, assists in diminishing the size of the thorax; second, it contributes, more than any other muscle, toward the diminution of the abdominal cavity; and, third, it acts in a manner analogous to that of the lower portions of the oblique muscles.

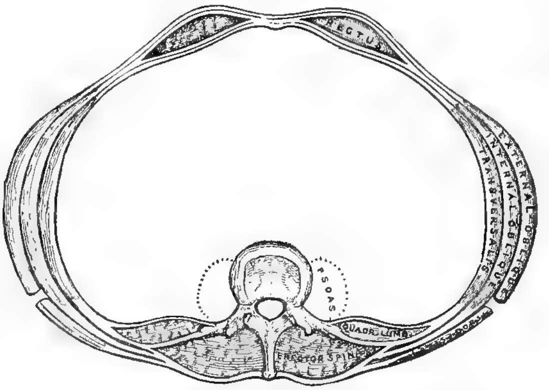

FIG. 1525.—Horizontal Section of Trunk Illustrating the Action of the Transversalis.

"Posteriorly, the most important muscles of forced expiration are the *erectores spinæ, serrati postici,* and *quadratus lumborum.*

"The *erector spinæ* is easily divisible into an outer and an inner portion, viz.: the *ileo-costalis* and *longissimus dorsi.* The former is connected below, by means of the lumbar aponeurosis, to the iliac bone; above, to the angles of the six or seven lowest ribs. The *longissimus* is more complex, but the only part of it which is prominently concerned in the respiratory function consists of a number of digitations running from the lumbar aponeurosis below to eight or ten ribs above.

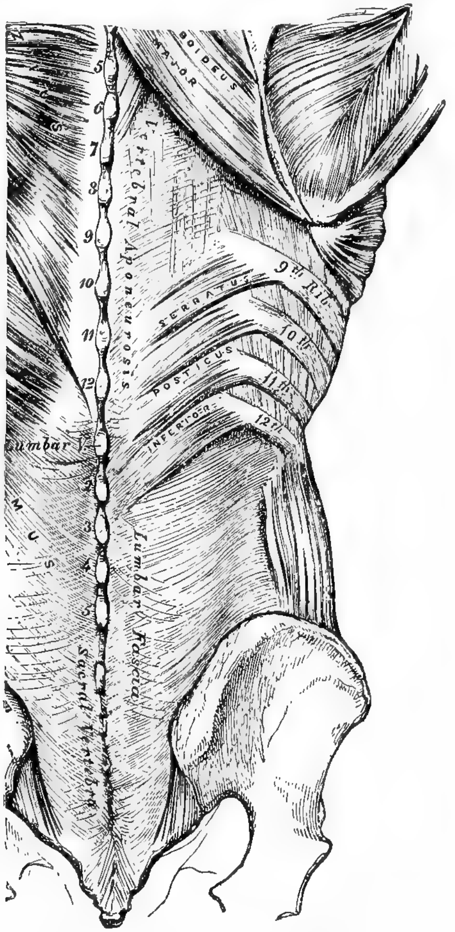

FIG. 1526. — Accessory Muscles of the Back—Serratus Posticus, Quadratus Lumborum.

"When the *erector spinæ* contracts, it draws the ribs forcibly downward toward the pelvis, lessens the transverse and antero-posterior diameters of the thorax, and at the same time tends to shorten the perpendicular axis of the abdomen. Those accessory muscles which reinforce the divisions of the *erector spinæ* above, act upon the upper ribs, but their strength is far inferior to that of the *ileo-costalis* and *longissimus dorsi* (Figs. 1526 and 1527).

"When these powerful muscles of expiration are spasmodically contracted in the act of coughing, their first effect is to adduct and depress the ribs, and by so doing diminish the size of the thorax in all its diameters. The adduction shortens the transverse diameter. The depression of the ribs and sternum shortens the antero-posterior diameter, and lessens the longitudinal axis of the general body cavity. But, as the abdominal walls only yield in the upward direction, and as the contents of the abdominal cavity are practically incompressible, its roof, the diaphragm, which is relaxed during expiration, must ascend and encroach upon the thoracic cavity, from which enough air escapes to compensate for the diminution in its size. The second effect of the expiratory contraction is to lessen the circumference of the abdomen. As the contents are incompressible, and as the sphincter muscles, by their contraction, prevent the escape of anything from the hollow viscera, the decrease in the transverse and antero-posterior dimensions of the abdomen must be compensated for by an increase in its long diameter—another factor in the production of the ascent of the diaphragm.

"This study of the action of the muscles during forced expiration will make plain the effects of coughing upon the lungs and other viscera. As has been already stated, the forcible expiration is preceded by a more or less deep inspiration, by which a large quantity of air is obtained for use in expelling the offending substance. The glottis is then partially closed, so as to narrow the route of exit and increase the friction of the escaping air against the mucous membrane of the larynx, trachea, etc. This is accompanied by the sudden and strong expiratory effort, during which the lower ribs are drawn quickly downward and inward, lessening the capacity of the lower portion of the thorax. The pressure upon the abdominal viscera drives them against the diaphragm, and pushes the floor of the thorax upward against the bases of the lungs. The lower lobes are then suddenly and violently pressed upon from all sides, and their contents driven in the direction of least resistance, viz., up-

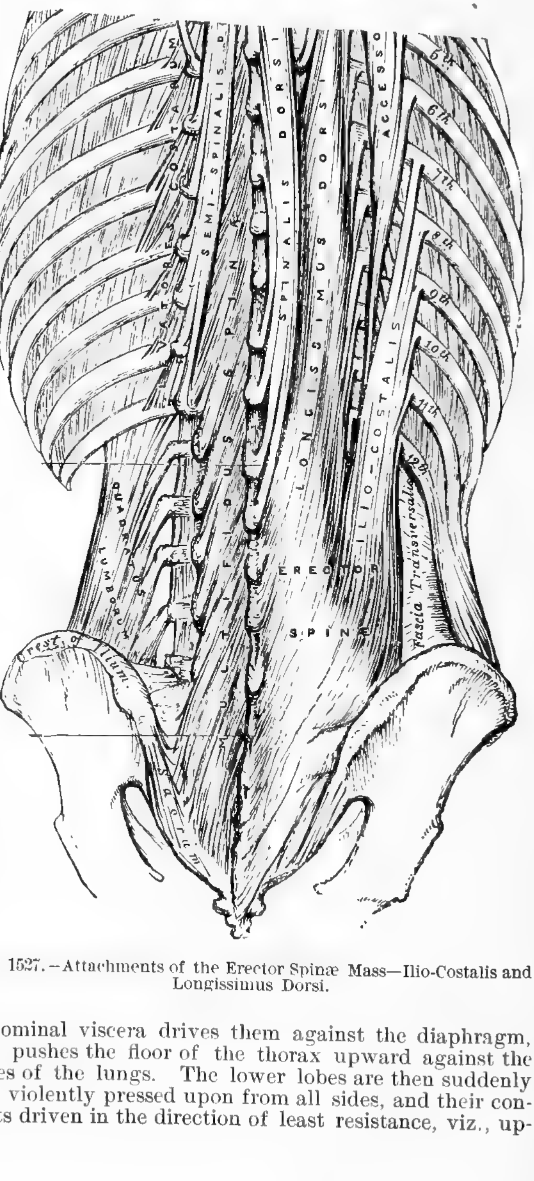

FIG. 1527.—Attachments of the Erector Spinæ Mass—Ilio-Costalis and Longissimus Dorsi.

ward toward the trachea. If the displacement of the air is so sudden that the pressure in the trachea is greater than in the bronchial tubes of the upper lobes, the current will be reversed in the latter, and the superior and anterior parts of the lungs will be inflated; for the apices and anterior borders of the lungs are very little subject to the expiratory force, and only expel their tidal and supplementary air properly when the movements of the thorax are sufficiently deliberate to allow of an adjustment of pressure throughout. The forcible distention of the apices is seen in those suffering from violent spasmodic cough, as in bronchitis, phthisis, and pertussis. During the paroxysms, the supraclavicular spaces are seen to bulge, sometimes to a very remarkable degree, partly from swelling of the large veins in those regions, but partly also from distention of the apices. The same thing can frequently be seen in the upper intercostal spaces, near the sternum.

"In acute bronchitis we find, as a result of increased expiratory efforts, both in breathing and coughing, a temporary distention of the alveoli of the superior and anterior parts of the lungs, manifested by prominence and increased resonance on percussion. It is a temporary functional emphysema which subsides as the attack passes away."

Diagnosis.—The most important point for a physician to determine in relation to cough is its cause, and the diagnostic possibilities, therefore, should be carefully considered. Its semeiological relations are by no means confined to diseases of the nose, throat, and lungs, although it is most frequently indicative of disease somewhere in the respiratory tract.

It may be caused by the inhalation of irritants, as dust, smoke, fumes, gases, volatile oils, and, in susceptible subjects, certain pollens, and odors. Changes of temperature, and excessive dryness and excessive moisture of the atmosphere may give rise to cough without exciting visible inflammation. It may be caused by undue heat or pungency of food or drink, or by even minute drops of fluid entering the larynx. It may cause or be caused by vomiting, or, as in nervous diseases, cough and vomiting may be due to a common cause. Similarly, cough may provoke or be provoked by laryngeal, pharyngeal, œsophageal, pulmonary, or gastric hemorrhage, or may be excited by blood from a nasal hemorrhage entering the larynx; or cough and hemorrhage may have a common origin. In such associations, therefore, care must be taken to examine the patient thoroughly, and to weigh duly all the facts of the case.

Coughing may be reflex in origin, as from the irritation of teething; or it may be due to foreign bodies in the ear, or to the existence of a tumor, inflammation, or other irritative disturbance in any portion of the auditory apparatus; or to foreign bodies, polypi, enlarged turbinals, and other abnormities in the nasal cavities, or to adenoid vegetations in the naso-pharynx. An elongated uvula, or a relaxed palate, or enlarged glands, or distended veins at the base of the tongue, may give rise to cough by mechanical irritation of the epiglottis; while cysts or other tumors upon the latter structure may produce either direct or indirect irritation, or provoke spasmodic cough with symptoms of strangulation by becoming incarcerated between the ventricular bands or the vocal bands. Foreign bodies or tumors in any portion of the throat (including under this heading, pharynx, larynx, and œsophagus), retropharyngeal abscess, a foreign body or a tumor in a bronchus, enlarged bronchial glands, a tumor or abscess of the thyroid gland, goitre, mediastinal tumor, aneurism of the thoracic aorta or its early branches, or of the right carotid or right subclavian artery, the pressure of a distended lung apex in emphysema,—any one of these may excite cough mechanically or by reflex irritation of the pneumogastric trunk or of one of its branches. Cough may likewise be due to cerebral disease, to tabes or other spinal affection, to neurasthenia, or to hysteria.

It may arise reflexly from irritation in any part of the digestive tract, including the liver, or may be due to congestion or œdema, secondary to disease of the liver, of the kidney, or of the heart. Its remote cause may be gout or alcoholism, and the most brilliant successes in treatment are sometimes due to the recognition of its gouty origin.

Cough occurs most frequently, however, as a symptom of inflammation, whether of the upper or lower respiratory tract: thus in sore throat of various localization, in epiglottitis, in laryngitis, in croup, in tracheitis, in bronchitis, in pneumonia (croupous or catarrhal), and in pleurisy; also in emphysema and in asthma. It is usually a marked feature in advanced cases of pulmonary tuberculosis, and sometimes in early cases, although in some instances pulmonary tuberculosis has been known to run its course from beginning to end with little or no cough.

The mere enumeration of these varied conditions, which, moreover, do not exhaust the list of possibilities, is sufficient to show that the cause of any cough must be carefully sought for both locally and in general conditions, and that unless both local and general examination has been made, no diagnosis can be considered beyond question. Laryngoscopy should never be neglected. Moreover, as in all other diagnoses, all of the facts in the case must be considered, and the decision based upon their association, rather than upon any individual symptom or sign.

Indications of greater or less significance may perhaps be given by the character of the cough. Thus a *ringing, metallic cough* is usually associated with pressure upon the pneumogastric nerve or its branches, and will thus be found in aneurism, mediastinal tumor, and similar conditions. A cough of this character or a peculiar *hoarse, stridulous cough* without expectoration, and associated with paralysis of the left vocal band, raises a very strong suspicion of aneurism even in cases in which all or most of the ordinary physical signs are lacking; and I have verified two such diagnoses, the one by fluoroscopy, and the other by post-mortem examination. A *muffled cough* suggests the presence of membrane within the larynx, and if the voice also be muffled, a high degree of probability is given to the diagnosis of membranous croup or diphtheria. The so-called *croupy cough*, or *crowing cough*, may be found not only in membranous croup and diphtheria, but in catarrhal and spasmodic laryngitis (false croup), and in laryngismus stridulus. The cough of asthma is of a hoarse, *wheezing character*. The *whoop* of pertussis is *sui generis*, and hence both characteristic and pathognomonic. Hysterical cough is often *staccato*, as is sometimes the cough of the insane, especially in the early stages of general paresis. It may, however, in hysterical subjects, assume almost any character, and the imitation of the cries of animals, more particularly the barking of a dog, or of the crowing of a rooster, is not uncommon. J. Solis Cohen has described an epidemic of hysterical barking in a seminary for young women.

Cough is said to be *moist* when accompanied by more or less pronounced sounds of agitation of fluid in the air passages, and in such cases it is usually associated with expectoration; though in the case of pulmonary œdema and other asthenic conditions, expectoration may be deficient. Cough is *dry* when not accompanied with expectoration, or when expectoration occurs only with difficulty and fluid sounds are absent. Cough is *productive* when it brings out a quantity of phlegm and ceases with such relief. It is unproductive when not so accompanied. Productive cough is sometimes termed *free*. The terms *prolonged* and *short, hard* and *light*, are self-explanatory. Coughs of the foregoing characters are usually associated with inflammatory conditions in some portion of the air tract, and their character may be an indication of the character of the causative inflammation. By *hacking cough* is usually meant a short, dry, unproductive cough, caused by mechanical irritation, or of reflex origin. "Hawking" of mucus from the nose or naso-pharynx into the throat should not be mistaken for cough. Sometimes cough is so severe as to cause the patient to become red in the face, and this is usually the case in spasmodic affections. A cough is *suppressed* or *deficient* when, in diseases that are ordinarily accompanied by free coughing and expectoration, weakness of the patient deprives it of this character.

The characters of the matters expectorated sometimes give valuable information as to the cause of the cough, or as to the pathological process with which it is associated. This subject is fully treated of under the heading *Sputum*, elsewhere in this HANDBOOK. Here I shall but refer briefly to the yellowish, muco-purulent appearance of bronchitic sputum; the greenish color and unpleasant odor of the discharge in bronchorrhœa; the dark, sometimes black, color of the sputum of pulmonary gangrene and its unmistakable putridity; the rusty sputum, prune-juice expectoration, and characteristic diplococci of acute lobar pneumonia; the sago-like, often black-spotted sputum of influenza with its characteristic bacilli; the greenish or nummular sputa of pulmonary tuberculosis with pathognomonic bacilli; the spirals and crystals of asthma; the membranous casts and Klebs-Loeffler bacilli of diphtheria, as illustrations. The entire absence of sputum suggests as the explanation of a cough, pleurisy, pulmonary tuberculosis, tumor or foreign body in the air passages, irritation of the epiglottis, pressure upon the pneumogastric nerve or its spinal accessory or recurrent laryngeal branch, or some reflex origin.

Coughing may be attended with *accidents* of greater or less moment and severity. Thus in acute bronchitis the lodgment of a plug of mucus so that the expiratory current is blocked may produce a temporary dilatation or emphysema, while in chronic bronchitis the emphysema tends to become destructive and permanent. So in cough of any character the closure of the rima glottidis and the backward pressure may produce forcible distention of the apices, that may even lead to rupture of air sacs, of intervesicular or interlobular septa, or of blood-vessels. This is especially the case in spasmodic cough, as in the unproductive effort of phthisis, or in pertussis. During the paroxysm the supraclavicular spaces bulge, partly because the apices of the lungs are distended, partly because of turgescence of veins. Circulatory disturbances are caused, mainly venous. As Westbrook pointed out, in ordinary breathing intrapulmonary pressure is slightly positive during the expiratory act. The forced expiration of cough causes sudden rise of pressure and arrests the current of blood in the large veins of the neck, chest, and abdomen, or may even reverse it. The blood from the right auricle and venæ cavæ is repelled upon the advancing blood. Thus the veins are overfilled in the stomach, the œsophagus, the pharynx, and the larynx, in the pelvis, in the inferior hemorrhoidal branches, in the uterus, in the vagina, and in the bladder, and ruptures and hemorrhages may occur. In women, bloody, serous discharges from the vagina, and in many cases involuntary urination, may occur during paroxysms.

In some persons the eyes bulge or feel a painful pressure during coughing, and hemorrhage of the conjunctiva, and even of the retina, may occur. Not only blood-vessels but other structures may give way under certain conditions. Dr. Max J. Stern communicates to me the case of a physician, aged seventy years, whose clavicle was fractured by the sudden strain of cough; and I have personally observed rupture of the fibres or ligamentous attachments of some of the deeper muscles of the back, incapacitating the subject for a number of days.

The severity of a cough depends partly on the nature, partly on the location, of the irritation or inflammation exciting it. The epiglottis is quite sensitive to irritation, and the reflex of cough readily producible. The superior compartment of the larynx (above the vocal bands) is much more tolerant, except that very slight irritation applied to a point on the meso-arytenoid fold will cause severe cough. On the whole, the greatest susceptibility is that of the mucous membrane of the lower larynx, trachea, and larger tubes, that is, below the vocal bands and above the smaller bronchi. At the latter, irritability diminishes, and the pulmonary parenchyma is still less sensitive. In pneumonia the cough is most largely due to the associated bronchitis; and, as already stated, coughing may be slight or absent in the early stage of pulmonary tuberculosis.

TREATMENT.—There is no treatment for cough; it may be restrained by the use of local or general sedatives, or stimulated by local or general excitation; but, as already stated, it is merely a symptom, and before it can be brought to an end its cause must be removed either through termination of the underlying disease in due course, or by surgical or medicinal intervention. It is often beneficial even when caused by pathological conditions, preserving its physiological function as an expulsive mechanism. It is only when excessive or unproductive that it needs to be restrained. When insufficient, on the other hand, it may need to be stimulated. Attention, moreover, must be paid to the character of the expectoration, correction of which, whether by stimulation or restraint, may be the only treatment necessary to bring the cough within proper bounds.

Cough caused by local irritation above the epiglottis —such as an elongated uvula, or a relaxed palate, adenoid vegetations in the naso-pharynx, nasal polypi, hypertrophied tonsils, or enlarged glands or vessels at the base of the tongue—is corrected by removal of the offending cause. The uvula may be partially amputated or treated with astringents or the electro-cautery. The relaxed palate may be treated with astringents or by means of electric applications. Hypertrophied tonsils, adenoid vegetations, nasal polypi, should be excised, burned, or otherwise destroyed. Enlarged glands or varicose veins at the base of the tongue should be destroyed, preferably by means of the electro-cautery point.

The cough that sometimes accompanies acute faucial and pharyngeal inflammations is relieved by the treatment of the causative condition. Ice, ice cream, and other cold sedative applications are usually most grateful. In rare instances inhalation of the vapor of hot water, medicated with opium, cannabis indica, hops, and the like, is more soothing. Chronic pharyngitis may be accompanied with cough. In such cases astringent lozenges, such as guaiac, catechu, or rhatany, usually help to relieve it. In singers and speakers especially, there may be cough due to lack of secretions in the mouth and throat. A lozenge that I have found quite useful in such cases contains ♏ ij. of the fluid extract of pyrethrum, gr. $\frac{1}{60}$ pilocarpine hydrochlorate, and ♏ ss. of oil of peppermint or an equivalent of menthol, or of camphor. It may be made up with chocolate, Irish moss, or the artificial "marshmallow" used by confectioners.

Cough due to acute catarrhal laryngitis is not usually excessive, and needs no treatment other than that of the affection of which it is symptomatic; for example, inhalation of the vapor of warm water impregnated with compound tincture of benzoin and paregoric. A spray of adrenal solution is useful in early cases. The cough of chronic laryngitis requires, as a rule, some special attention; it is usually unproductive, and as it is a source of distress, and also mechanically prolongs the irritation and inflammation of the organ, may need to be restrained by sedatives. Of these, the bromides or opiates in very small doses are preferable. The new synthetic preparation of opium, heroin, is much lauded, but has no special advantage over morphine or codeine. The latter is to be preferred in cases in which an alkaloid of this drug is to be used, as it is less likely than is morphine to produce an unfortunate habit. On the whole, however, paregoric will serve the best of the opium group; gr. x. of strontium bromide and ♏ xv. of paregoric given with syrup of garlic or with mucilage of acacia three or four times a day, usually answers every purpose. A cold compress over the front of the neck is often useful in cases of subacute and chronic inflammations of the larynx, and incidentally helps to restrain cough. It is usually applied most conveniently during bedtime. Sprays of zinc sulphocarbolate and the like, or of wine of ipecac, may be used during the day. Morphine oleate (two per cent. in oleic acid) applied externally over the larynx, or endolaryngeally by sponge and carrier, sometimes has a useful sedative effect. When the cough of chronic laryngitis is obstinate and troublesome, and not relieved by the method applied to the treatment of the underlying affection, relief may sometimes be given by the administration of cimicifuga, gtt. x. or xv. of the fluid extract, three or four times a day. In cases dependent on congestion due to deficient cardiac action, digitalis, strophanthus, strychnine, and other cardiants, are usually efficient without special sedative treatment; but bromide or opium may be used with caution in these cases also. A small dose of morphine, say gr. $\frac{1}{60}$ to $\frac{1}{30}$, may be combined with some stimulating sialagogue or expectorant, as cubeb or pyrethrum, in a lozenge. As a rule, however, lozenges are not useful in checking cough, except when this is due to local conditions above the epiglottis.

In acute bronchitis, if the cough is easy and the expectoration free, no special indication is afforded for treatment. When the cough is hard and expectoration difficult, a stimulating, expectorant treatment is useful. Ammonium chloride stands at the head of drugs used for this purpose. Its taste, when disagreeable, may be covered with fluid extract of coca or with the powdered extract of licorice, in syrup of tolu or syrup of senega. Paregoric may usefully be added to such a mixture when the cough partakes of an irritative character. In subacute and chronic bronchitis cough is usually due to insufficient fluidity of the secretions, so that they cannot be expelled readily. The terebinthinate and balsamic group of drugs is here of the greatest service. Eucalyptol and fluid extract of eucalyptus, oil of sandalwood, oleoresin of cubeb, turpentine, terebene, and terpine hydrate, are most frequently employed. Myrtol is perhaps better than any of the preceding. The general dose of the volatile oils is from gtt. x. to xv. in emulsion or capsule, or given upon sugar. Of terpine hydrate the usual dose is about gr. v. Small doses of apomorphine or of pilocarpine or of fluid extract of pyrethrum, may be used with discretion. When expectoration is too great and cough too frequent, aromatic sulphuric acid and codeine are among the drugs most useful. Tincture of belladonna, atropine sulphate, or extract of hyoscyamus, in small doses, or, when there is a distinctly neurotic element, hyoscine hydrobromate (gr. $\frac{1}{200}$ or less) may be cautiously used in cases of excessive secretion, or of spasmodic cough.

In pleurisy, cough becomes painful. Strapping of the ribs tends to restrain it, and, by restraining breathing as well as cough, to relieve pain. When this does not suffice, codeine or other opium preparation should be given, when the pain is so great as to justify interference or to interfere with the patient's prospects of recovery; otherwise no interference is necessary. Hot applications, or ointments containing guaiacol, menthol, and birch oil well rubbed in externally over the seat of pain are often useful in restraining the irritation that produces cough. Sometimes a light blister acts happily.

In pneumonia it is unwise to try to check cough, as is so often done, by the administration of opium; especially unwise is the hypodermatic use of morphine. The greatest judgment is needed to determine whether or not to interfere, and, in the latter instance, the nature and character of the interference. Cough should be sufficient to permit of free expectoration of the matters contained in the bronchi. On the other hand, it should not be so frequent or so painful as to prevent the patient from sleeping or add to his physical or mental distress. Usually expectorant drugs, of which ammonium chloride and ammonium carbonate stand at the head, are given with good results upon the general progress of the case. Senega, squill, cimicifuga, and the like may be useful, though they should not be employed merely for a secondary influence upon the cough, if not otherwise called for. The inhalation of ethyl iodide also tends to render expectoration freer and to diminish irritation, and thus to keep the cough within due limit. Should it be necessary, as in rare instances it may be, to take active measures to restrain coughing, the cautious inhalation of chloroform or of the *ammoniated chloroform* of B. W. Richardson is to be preferred. The chloroform is best carried over by means of oxygen passed through a wash bottle containing it. Nothing approaching general anæsthesia should be produced. The relaxation of the vaso-motor system is not dangerous in pneumonia, if not pushed to excess. Indeed, the administration of nitroglycerin sometimes relieves cough by diminishing pulmonary congestion and relieving the heart. Similarly the use of digitalis at the appropriate time, and venesection judiciously applied, while not to be prescribed merely for the relief of cough, include this in the sum of their effects. Nitrous oxide may also be used with caution. It is best given mixed with oxygen in the proportion of one part of the former to two of the latter, and may be inhaled after being passed through a wash bottle in the ordinary way. When inhalations are not available, spirit of chloroform, hydrocyanic acid, hyoscine hydrobromate, and if necessary, codeine, may be cautiously employed by internal administration. Some physicians administer tartar emetic in doses of gr. $\frac{1}{24}$ or less to an adult to promote secretion and thus to lessen cough. I have never used it for this purpose.

In asthenic conditions, as hypostatic pneumonia, pulmonary œdema, capillary bronchitis of the old and debilitated, and sometimes in infants, cough is deficient. It then needs to be stimulated. Opium and depressants should be avoided, and such agents as strychnine, turpentine, digitalis, mustard oil well guarded, musk, ammonium carbonate or aromatic spirit of ammonia, quinine, hydrogen dioxide, and oxygen should be used.

The cough of pulmonary tuberculosis requires very skilful management. The tendency both of patients and physicians is to try to suppress it. This is a mistake, as it is of the utmost importance for the patient to free the air passages from the morbid accumulations. The cough may be regulated, but no effort should be made to bring it to an end, except naturally as an indication of progress toward recovery. The inhalation of compressed air, especially if conjoined with expiration into rarefied air, tends at first to increase cough by facilitating the expectoration of matters otherwise retained in unventilated regions of the lung. Later the diminution in the quantity of morbid product tends to reduce the cough. The cough is often favorably influenced by the other features of the hygienic treatment, especially by hydrotherapeutic procedures, of which the simplest is the morning cold sponge or shower bath. All medicaments advocated for use in tuberculosis, whether by the laity, by quacks, by physicians, or by those who belong partly in all these classes and wholly in none, number among their alleged virtues the lessening of cough. This is, in fact, true of creosote and its derivatives and congeners, and of the balsamics and terebinthinates, of which latter cinnamic acid (sodium cinnamate), Peruvian balsam, eucalyptol, terebene, and myrtol are the best. Ethyl iodide, creosote, chloroform, bromoform, oil of peppermint, and the terebinthinates and volatile oils in general are useful by inhalation. Singly or combined in various proportions they may be inhaled from the vial, or from the sponge of Dr. Burney Yeo's perforated zinc respirator.

Stomach-cough, liver-cough, etc., and the cough of rheumatic or gouty bronchitis, laryngitis or pharyngitis, must be overcome by appropriate constitutional treatment; but strontium bromide may usefully form a part of that treatment, and often helps to allay cough.

Whooping-cough is often unamenable to medicinal treatment, and the best remedy is to send the patient, if possible, to the seashore, to be kept in the open air as many hours out of the twenty-four as the sun shines, and as otherwise may be advisable. Among palliative remedies inhalations of various kinds have been recommended. The vapors produced in the manufacture of coal gas, inhaled at the gas works, have a popular reputation not wholly undeserved. Ozone, hydrogen dioxide, hydrofluoric acid, chloroform, ethyl iodide, and bromoform, have all been highly recommended by competent observers, and are doubtless useful in individual cases. The vaporization of menthol or eucalyptol, or both, day and night in the rooms occupied by the patient, and in sufficient quantity to be easily discernible upon entering the room from the outer air, is useful. Creolin, carbolic acid, and various coal-tar and coal-oil products under proprietary names, have been advised for use in a similar manner, and all of them have proved beneficial in a certain number of cases. Toxic effects may be produced by the absorption of such drugs, and the same care must be observed as in the case of internal administration. Formaldehyde solution (formalin) has been advised for inhalation, well diluted, from an inhaler on the plan of a Wolff bottle. The terebinthinates, of which eucalyptol is best, may be dropped on a sponge suspended like a locket from a tape about the child's neck, or held over the nose and mouth by the Yeo respirator, and thus the respired air be continuously medicated.

A new preparation of fluorine, difluordiphenyl, has been advised in the form of an ointment, under the proprietary name of antitussin, and the reports in its favor are accumulating. My own experience with it, however, has not been brilliant.

As to internal medication, the collateral bronchitis should be treated on general principles, and to allay cough, bromoform seems on the whole the most useful of all the drugs that from time to time have been recommended, of which the name is legion. To a child two years old gtt. ij. bromoform in glycerin and sherry wine, or in aromatic elixir, may be given every two, three, or four hours, as may seem necessary. In every instance, however, the dose must be adjusted to the age and susceptibility of the patient and the severity of the case. Hydrogen dioxide has, in my hands, proved useful in doses of from ♏ xx. to lx., diluted with glycerin and water, and given every third or fourth hour. Sulphurous acid, sodium hyposulphite, and Hope's nitrous acid mixture seem also to have some usefulness. Sprays of adrenalin have been advised, but I have as yet had no opportunity to gain experience with this measure.

Laryngismus stridulus is usually an accompaniment of rhachitis, the constitutional treatment for which must be instituted. In addition, amyl nitrite inhalations may be used to relax the spasm, and care is necessary to guard against strangulation of the child by incarceration of the epiglottis. Nitroglycerin or sodium nitrite given internally for prolonged periods, in doses appropriate to the age of the patient, sometimes has a beneficial effect in diminishing the frequency and severity of the paroxysm.

Tumors and foreign bodies are to be removed if possible.

Retropharyngeal abscess is to be treated surgically, and the associated cough will disappear. Enlarged bronchial glands are not as yet susceptible to direct treatment, but crystallized calcium chloride, given internally in some suitable vehicle, in doses of gr. x. or xv. three or four times daily for a child of seven or eight years, and proportionately larger doses for older persons, often exerts a beneficial influence upon glandular enlargements in general. So, too, the so-called alterative treatment with preparations of iodine, of arsenic, and of mercury, is often useful. When glandular enlargements are due to syphilis, tuberculosis, or other recognizable cause, that will furnish the indication for treatment.

The cough of asthma is rather to be encouraged than diminished, as free expectoration will sometimes assist in cutting short the paroxysm. Otherwise the treatment is that for the underlying condition, and need not here be discussed. The cough of hysteria can be controlled only by psychic influence, the physical medium of which may be an electric application, a blister, or other means, according to the individuality of the patient and of the physician. In my own observation painful electric applications to the larynx or over it have been the most successful; though these should be made only with great caution, and never by those inexperienced in the use of electricity in the neighborhood of the pneumogastric nerve.

Solomon Solis Cohen.

COUNTER-IRRITATION.—(See also *Cauterization.*) This is a remedial measure the object of which is to produce a congestion of the vessels at the surface of the body for the purpose of relieving a disturbance of some remote tissue or organ.

The principle of counter-irritation is followed in many therapeutic methods of a general character, all of which relieve internal, or more or less localized, congestions. Those best known are hot baths, steam baths, hot foot baths, heat to the extremities, blood-letting, etc. These general methods, however, are not known as counter-irritants; the term is commonly restricted to such as are more local in their action and which are employed to accomplish a definite object. For this purpose various irritant drugs are utilized, as well as the actual cautery, dry-cupping, and other similar means which cause a local irritation.

The irritation produced by counter-irritants varies in degree, and the difference is expressed by the terms rubefaction, vesication, and pustulation, according as they simply redden the skin or produce a blister or a pustular eruption. These terms do not imply sharply defined groups, as one may merge into the other, and a single drug may cause one or all of these effects according to the strength of the preparation or the length of time it is applied.

Rubefacients are such as produce a reddening and congestion of the skin, the vessels becoming dilated and the supply of blood increased. The effect is immediate, but of short duration, as it rapidly disappears when the irritation is removed. When the application is prolonged it causes a severe inflammation of the skin which may result in vesication or ulceration. For this reason rubefacients require to be applied with some care to children and others whose skin is thin and sensitive, as the irritation may be unnecessarily severe. The same caution is necessary when they are applied to the skin of those who are unconscious or in whom the sense of pain is impaired.

Mustard, ammonia, turpentine, camphor, and iodine are the best known of this group.

Vesicants.—In vesication there is a deeper and more severe inflammation of the skin which results in an effusion of serum beneath the cuticle. If the application is prolonged the effusion of serum may be very great. The counter-irritation may also be prolonged for days or weeks, by the application of irritating substances to the denuded surface, after the effused fluid has been removed. In selecting a site for the application of a vesicant it is advisable to avoid any bony prominence, as there may be trouble afterward as regards the healing of the spot. A depressant effect is apt to accompany blistering, and this may become a serious affair if the patient is weak or if the blistered surface is very extensive.

Cantharides is the one drug that is almost entirely used for this purpose. The cerate, spread in the form of a plaster, is the preparation generally employed. It is slow in its action and requires to be kept applied for about eight hours. To increase its action, camphor, ether, acetic acid, and the powdered drug may be applied to the surface. Hot linseed poultices may also be applied after the removal of the plaster, to promote the effusion of serum. Some caution is necessary during the employment of cantharides, on account of the liability of its being absorbed and exerting an irritant effect upon the kidney. If there is any tendency to kidney disease this caution is particularly required. Acetic acid is a very efficient solvent of cantharidin, and the Liquor epispasticus of the British Pharmacopœia possesses a much more rapid action than any other preparation, one application being generally sufficient to cause a blister in the course of an hour. Cantharidal collodion is also an effective preparation, but less rapid in its action than the above.

Ammonia is sometimes employed as a vesicant, but it is less effective and very painful. A piece of lint is saturated with the water of ammonia and kept in contact with the part.

Hydrochloric acid is also sometimes used, the pure acid being applied to the surface.

Pustulants.—Croton oil and tartarated antimony are typical representatives of this group. Their application results in a pustular eruption accompanied by much inflammatory action. The course of the eruption is similar to that of the rash of smallpox, the formation of pus persisting for several days and leaving the part deeply pitted and scarred. On account of the severe effect which they produce, pustulants should not be extensively applied, nor should they be applied to any exposed part for fear of causing disfigurement..

Croton oil is the pustulant generally employed. When pure the oil is too strong to be used undiluted, and olive oil or spirits are added until the croton oil is reduced one-half.

Tartar emetic in the form of an ointment, one part to four, was formerly much used. It is now rarely employed, as its action is slow, and severe depression may result from absorption of the drug.

The *actual cautery* is particularly serviceable, as by its careful use the physician may establish any degree of counter-irritation. By simply passing the heated iron over the surface of the skin, but not in actual contact with it, he may produce the mildest rubefaction; and if a more severe effect is required, he has only to bring the point of the cautery lightly and quickly in contact with the skin. Very little experience is required to enable one to produce almost any degree of counter-irritation immediately, and readily to control the action of the heated instrument. Any form of actual cautery may be used, but the thermo-cautery is that usually adopted. A very old and simple method is to place an ordinary metal spoon in hot water for a few minutes and then to apply it to the part. It is stated that if the spoon, which has been heated in water at 120° F., is kept in contact with the skin for three seconds, the part will become red and congested, and that if it remains for ten seconds, vesication will follow.

Dry-cupping is a means of counter-irritation that is still frequently resorted to. It produces a rapid and intense rubefaction which persists for some time (see *Blood-Letting*).

Formerly a prolonged counter-irritant effect was produced by the use of *setons* and *issues.* These are not resorted to at the present day, although an occasional reference is made to their value by the older surgeons.

Setons were artificial sinuses formed by pinching a fold of skin and subcutaneous tissue, and, with the aid of a seton needle, passing through it one or more strands of silk, cotton, hair, or some such material. This was left in place and each day moved back and forth. The object was to promote suppuration, and, in order to increase the irritation, some caustic preparation was often applied to the material.

Issues were wounds artificially produced and maintained for the purpose of securing a continuous discharge of pus. When a small issue was desired, the wound was simply an incision made by a knife. When a more marked effect was required, caustics and moxa were resorted to to destroy the part. Various methods were adopted to maintain the discharge, such as the introduction of peas and beads, irritating drugs, and caustics.

Counter-irritation is resorted to for three purposes: to relieve pain, to lessen congestion and inflammation of deep-seated organs, and to promote the absorption of the products of inflammation. In selecting the particular counter-irritant by means of which it is hoped to attain these ends, the degree to which it acts must be the guide for its employment. If the trouble is of recent origin, or if the organ is simply a little congested, a mild counter-irritation will usually prove sufficient; but if the disturbance is of longer duration and especially if structural changes have begun, then a more severe and prolonged effect is required. The immediate effect of rubefacients is much greater than that of vesication and other more active irritants, but the remote effect is much less. For this reason they are selected at the onset of pleurisy, bronchitis, pulmonary, and renal congestion, neuralgias, colic, and gastric pains; the extensive reddening of the surface in the neighborhood of the part affected affording immediate relief. On the other hand, when the inflammation is established as in advanced bronchitis, pleurisy, endocarditis, peritonitis, sciatica, inflamed joints, and such serious affections, vesicants, pustulants, and the actual cautery produce a prolonged and more effective counter-irritation.

Although the beneficial effect of counter-irritation is very evident, the manner in which it is produced is as yet undetermined. It has been thought to depend upon a direct vascular relation between the affected organ and the adjacent skin surface. This explanation is applicable to superficial and intercostal neuralgias, to inflammation of the costal pleura, and to many joint affections, when there is a blood supply common to both parts; but it is not sufficient to explain the relief afforded to deeper parts which have an independent circulation. The more recent and probably the more correct explanation is that which looks to the sensitiveness of the cutaneous nerves and their reflex action upon the deeper parts. The activity of the superficial reflexes is evident to all, and experimental work has shown that a similar influence is exerted on the deeper organs, as where an irritant to the skin over the kidneys causes a contraction of the renal vessels, or where, in an exposed pia mater, the vessels are similarly affected by irritating the scalp. Further evidence of this relation between the deeper parts and the surface is furnished by the many reflected pains that arise when the organs are diseased. Starting from this explanation as a basis, we may maintain that a careful mapping out of the skin areas most intimately associated with the various organs beomes necessary; and when such a scheme has been prepared, it will at once be possible to employ counter-irritants in a more rational and effective manner. *Beaumont Small.*

COWPER'S GLANDS.—These glands were discovered by Cowper in 1700. They are two in number and have a genital function the exact nature of which is not definitely known. Probably their function is to lubricate the urethra during sexual excitement, at the same time adding somewhat to the volume of the seminal fluid at the moment of ejaculation.

It has been demonstrated that their activity is much increased by sexual excitement. In a case of a cyst of one of Cowper's glands which was opened externally, the fluid excreted through this opening was markedly increased at the time of erections. It is not believed, however, that these glands have an important part in propagating the species. They are believed to be entirely accessory in their function and that their absence would not particularly influence the sexual act or its results. I cannot find any statement in the literature of the subject which would tend to disprove the above belief.

The subject, however, has not been very thoroughly studied, either as regards the function or as regards the pathological conditions of these little glands. I am of the opinion, from my own experience, that they are diseased more frequently than is generally supposed, but that the resulting pathological conditions are not always recognized. Owing to the position of these glands and their ducts they are frequently in the path of a gonorrhœal infection, and an infection of these bodies may be so mild as to make a differential diagnosis extremely difficult until possibly, by urethral or external irritation, one of the glands becomes acutely inflamed, producing a characteristic swelling and train of symptoms.

I believe that in certain cases of chronic relapsing urethritis of a gonorrhœal origin, where no focus for the discharge can be found and where the urethra, seminal vesicles, prostate, and other parts are normal, a disease of one of these glands is the cause of the persistent discharge. I have seen a few cases of the kind, and in one of these a most prolonged discharge was cured by the enucleation of Cowper's gland during a period of acute exacerbation produced by urethral instrumentation. This case had been stirred up by sounds on several occasions, the inflammation being accompanied by increased discharge and pain in the perineum. I saw the patient in one of these relapses, and found an inflammation with the usual symptoms of a suppurating Cowperitis of a relapsing character. An operation, as above stated, cured the patient. Such a case demonstrated the importance of considering a case from all sides and getting at the root of the trouble. We should give up the empirical method of treating a discharge by the invariable anterior injection. Instead, we should find the focus of the trouble, treat that, and the discharge will subsequently cease. In cases of Cowperitis of the chronic, low-grade character just described, it can readily be seen how ridiculous and unsatisfactory it would be to use an anterior urethral injection.

I have spoken of diseased conditions of these glands only in a general manner, but I will presently take up their special disorders, with their appropriate treatment. Before doing this, however, I shall refer to the anatomical position of these little bodies.

They are about the size of peas, placed one on each side of the median perineal line beneath the forepart of the membranous urethra, between the two layers of the perineal fascia, and close behind the bulb. They are enclosed by the transverse fibres of the compressor urethræ muscles. Each gland is made up of large acini with wide lumina invested by a fine connective-tissue capsule and with much involuntary muscular tissue in their parenchyma. These acini are lined by clear columnar cells and they open into one common duct, where, combining with the ducts of the other lobules, they form a single excretory duct. These ducts, one for each gland, are slender and whitish in appearance, run forward obliquely for about one inch beneath the urethral mucous membrane, and open by minute orifices into the floor of the bulbous portion of the urethra.

These glands are present at all periods of life, but they diminish in size in old age.

Their pathological conditions have not been studied as thoroughly as have those of other parts of the genito-urinary tract. In the literature of the subject an occasional case has been reported. During the past five years, in private and dispensary practice, I have met with only half a dozen cases of Cowperitis of a type pronounced enough to be recognized.

Cowper's glands may be involved in the course of an urethritis of any kind, but more frequently in the course of one of a gonorrhœal origin; they may also be affected by trauma, by tuberculosis, by cysts, and by malignant disease.

Cowperitis as a complication, either direct or indirect, of a gonorrhœal urethritis is the form usually seen. This complication is not likely to occur before from three to four weeks after the commencement of the gonorrhœa, and may not appear until much later.

The disease usually begins with considerable pain in the perineum, accompanied by a tumefaction in the mid-perineal region, slightly to one side. I have never seen both glands involved at the same time, although in a severe case, if the condition has been present for some time, there may be a general tenderness and swelling over the whole perineum, and only very obscure indications of the fact that the gland was the original starting point of the infection. Besides the tumefaction, which is apparent both externally and upon exploration by a finger introduced into the rectum, there will be more frequent periods of urination with probably considerable pain at the end of the act, owing to the pressure on the involved gland by the compressor urethræ muscle. There usually will be a diminution in the size of the stream. There is fever in many cases, particularly if suppuration is present or impending. An attack may, however, begin and then gradually subside before there is any pus formation. In all cases, sitting or walking becomes extremely painful, and any pressure on the perineum causes much discomfort.

At the beginning of the trouble a finger introduced within the external sphincter of the rectum will enable the surgeon, with the other hand placed over the perineum, to recognize this condition. The fact of the swelling being on one side of the perineum is a matter of importance in the differential diagnosis.

When suppuration occurs the symptoms are much aggravated. There are severe throbbing in the perineum, fever, much difficulty in urination owing to mechanical obstruction, and occasionally retention, all combined with extreme pain. The abscess may break into the urethra, or externally. It is, however, more likely to break externally. In some cases a troublesome cicatrix remains. In rare cases the abscess breaks into the urethra, but urinary extravasation in such cases is unusual. In patients in whom these glands become involved following gonorrhœa and in whom after being inflamed they subside without suppuration, they are liable to relapses of the old trouble on slight provocation; as after slight injury of the perineum, a gonorrhœal urethritis, the introduction of urethral instruments, deep injections or irrigations, excessive sexual excitement, indulgence in alcohol, high living, and the like. In such cases, with a dormant focus of gonorrhœa in one of Cowper's glands, the patient will have an occasional discharge which resists all forms of treatment directed toward other parts of the genito-urinary tract. The inflammation in the intervals may be so slight that the cause of the trouble in Cowper's gland is not recognized. In fact, I am confident that some chronic discharges of a relapsing character are due to disease of one of these little glands. It is an extremely difficult matter to diagnose a chronic condition of this kind owing to the position of the glands and their ducts and also owing to the small amount of local disturbance in such cases. This condition may be called a relapsing Cowperitis, indirectly caused by an old gonorrhœal urethritis. The gland, of course, has never recovered entirely from the first acute infection, and unless the disease is stirred to activity by some chance cause, as instrumentation, it may not be recognized for years; the discharge, which is obstinate to all treatment, being the only evidence of any disease. I also believe that stricture may follow a severe Cowperitis of this character.

By obtaining a careful history of the case as to any acute attacks of Cowperitis, by making a thorough examination of the seminal vesicles and prostate with a finger educated to the rectal feel for any disease of these organs, by instituting a urethral examination with sounds, and by the employment of the endoscope we should be able to form an opinion in many cases as to the part diseased. The treatment should, of course, be adapted to the conditions thus ascertained. If one of Cowper's glands is enlarged and is demonstrated to be the cause of this relapsing discharge, it should be enucleated without further delay.

Fuller, in his book on "Disease of the Genito-Urinary System," says, "The prognosis as regards suppurative cases if treated expectantly is not very favorable. In many of them a sinus persists marking the path of exit of the original abscess. From such sinuses there is usually a slight urinous leak, that fluid finding its way into the path of the duct which previously connected the gland with the urethra. In some cases a sinus persists because the original abscess cavity is filled with unhealthy granulation tissue developed chiefly from the remains of the glandular structure. Such tissue continually secretes pus, and should the sinus furnishing the vent become closed, then a chronic burrowing will occur and another sinus will eventually be established. In this manner at times the perineum may become filled with cicatrix and fistulæ."

The treatment of non-suppurative cases should be the external application of ice or of soothing lotions, over the perineum, and rest in bed, with all pressure removed from the perineum.

No hot applications should be used, as such treatment might tend to promote suppuration. All urethral treatment should be discontinued. It is well to give some drug by the mouth to render the urine bland; acetate of potash, gr. v. to x. every three or four hours, is often serviceable. If there is very severe pain, anodynes had better be employed. A very efficient method of employing them is in the form of a rectal suppository having the following composition: Ext. opii, gr. i.; Ext. belladonnæ, gr. ¼. A second such suppository should be introduced at the end of from four to six hours if the pain continues to be severe. The bowels should be thoroughly moved, but the use of rectal irrigation is not usually desirable in acute Cowperitis, as the introduction of the nozzle is liable to cause considerable pain, thus stirring up an already very sensitive region, and probably doing more harm than good.

In other cases, in which we are convinced, from an increase in the severity of the signs and symptoms—viz., a more pronounced tumefaction in the perineum, more severe pain of a throbbing character, the presence of fluctuation in the swelling, the rise in body temperature, etc. —that suppuration is present, it will be evident that an incision should be made. This should be done with the usual surgical care. After evacuating the pus the remainder of the diseased gland should be removed and the wound packed lightly with gauze; then a soft-rubber catheter should be introduced through the penis into the bladder and left there for permanent drainage. As the discharge gradually becomes less the edges of the wound should be drawn together.

In cases in which there is an extravasation of urine into the perineum and surrounding tissue, free incision should be made as early as possible. If, after the acute symptoms subside, a permanent urinary fistula should remain, a radical operation will have to be performed and the old inflammatory tissue removed, a urethral soft-rubber catheter being left in place till the wound heals. If there is no communication between the wound and the urethra, the diseased area lying entirely outside the latter, it will be found desirable to introduce a sound into the urethra as a guide during the operation. No radical operation should be undertaken while there are any remains of an acute gonorrhœal urethritis.

Cowperitis may be produced by trauma, as a blow over the perineum, horseback or bicycle riding, and the like. However, most of the disturbances arising from such causes are the indirect result of a gonorrhœal urethritis of long standing, which has been roused to renewed activity by the injury. The treatment is the same as that already described above. In one case of mine the patient was not seen for some days after the injury and the whole perineal region was found to be tumefied and extremely sensitive. The case was one of an old gonorrhœa of Cowper's glands which had been of a relapsing character. The injury had been produced by the use of large steel sounds.

A tuberculous condition of Cowper's glands may occur, and Fuller, in his book, refers to a case in which severe horseback riding was followed by a non-suppurative Cowperitis with suppuration of the inguinal glands. The removal of these by an operation revealed the fact that they were tuberculous. The Cowperitis subsided without operation, but Dr. Fuller believed that this affection also was of a tuberculous nature.

In a patient with a predisposition to tuberculosis an inflammation of Cowper's gland produced by mild trauma, with no previous gonorrhœa, should cause us to suspect tuberculosis.

If the disease does not go on to suppuration, constitutional treatment and change of climate are indicated. On the other hand, if suppuration should occur, the removal of the diseased gland will be clearly indicated.

A few cases of cyst of Cowper's gland have been reported; they projected into the urethra and thus diminished its calibre. If such a cyst is large enough to obstruct noticeably the flow of urine, it is clear that it should be removed by operative interference. This can be done by making an incision through the perineum into the urethra, and then closing the wound after the removal of the cyst.

Very few instances of malignant growths of Cowper's glands have been reported. They appeared in the form of a hard, movable nodule in the region usually occupied by the gland. In structure they usually presented the appearances of a cylindroma.

Such a growth may in a short time obstruct the flow of urine. The growth is rapid and at first painless, but as the tumor increases in size the patient notices pain in defecation, difficulty in sitting or walking, and in all positions which cause pressure upon the growth. The inguinal glands become involved. A combined rectal and abdominal examination will indicate the position of the tumor as readily as it does in cases of simple swelling of the gland. An early removal of the gland and other involved parts is the only form of treatment which offers any hope of success. *Follen Cabot, Jr.*

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COWPOX.—(Synonyms: Vaccinia, Vaccine Disease, Kinepock.) Cowpox is a specific contagious disease, occurring in the cow, horse, and possibly in other domesticated animals, characterized by an eruption which closely resembles in anatomical structure and successive stages of development the eruption of variola.

The disease known as *grease* in the horse is believed to be identical with, and capable of producing, by inoculation, vaccinia in the cow. Vaccinia chiefly affects young cows, and the eruption is nearly always limited to the udder and teats. It rarely, if ever, occurs more than once in the same individual.

Cowpox occurs sporadically and as an epidemic. It is susceptible of propagation by inoculation, but is contagious in no other way.

The disease prevails more extensively in the herds of Europe than in those of this country, but is far from common anywhere; in fact, previous to the discovery of the Cohasset stock in 1881, no perfectly authenticated case of natural cowpox had ever occurred in America.[1]

The constitutional symptoms are mild, and the malady would possess little practical importance were it not that, reproduced in man, it either confers absolute immunity from smallpox, or greatly modifies its course and mortality. After a period of incubation lasting from five to eight days, the udder becomes hot, tender, slightly swollen, and small, red papules appear upon the udder and teats. The papules, about five days after their appearance, are changed into vesicles, distinctly umbilicated, and filled with transparent, amber-colored lymph. When not influenced by location or surroundings, the vesicles are circular in form, and vary in size from one line to five lines. They are encircled with a rose-red areola and a well-marked zone of induration.

On section each vesicle is seen to be multilocular; its interior is divided into several distinct chambers containing lymph, and separated from one another by delicate partitions.

The transformation into pustules is fully completed by the eleventh or twelfth day, the central depression disappears, and the external contour is conoidal. The local inflammation soon abates. Desiccation advances rapidly, and by the fourteenth or fifteenth day crusts of a dark mahogany color are fully formed. These fall off about ten days later, and whitish scars, more or less deeply pitted, mark the site of the vesicles.

The lymph and crust may be used in inoculating other heifers or in human vaccination; but the former, collected when the vesicles are from seven to nine days old, is, for obvious reasons, greatly to be preferred.

Vaccinia may be produced in the cow by inoculation with lymph from animals affected with the disease, with humanized virus, and with the lymph of variola.

The essential features are the same by whatever method produced, but vary in intensity.

At one time retrovaccination, or the inoculation of heifers with humanized lymph, was extensively practised, especially in Italy, in the belief that the supposed deterioration of human vaccine virus could in this way be prevented and all contaminations removed. The practice is now justly abandoned.

The true nature of cowpox has given rise to much discussion in professional circles and this discussion cannot yet be considered closed. It is questionable whether the disease ever originates spontaneously. The weight of opinion tends strongly to support the view originally advanced by Jenner, that the vaccine disease is variola modified by transmission through the system of the cow. The French school still indorses the conclusion of the well-known Lyon Commission (1865) as to the dual nature of the two diseases. It is, however, very difficult to produce the disease by inoculation with smallpox virus. But few of the many experimenters have succeeded, and at times very lamentable results have followed the attempt. In several instances widespread and fatal epidemics of genuine smallpox have been kindled by the use of virus obtained from bovine variolation. In confirmation of this statement we may cite the experiences of Martin in Attleboro, Mass. (1836), Reiter in Munich (1839), and the Lyon Commission (1865). In determining questions of this kind, one successful experiment rebuts the negative testimony of many failures. Mr. Ceely, of England, than whom there is no higher authority, Hime (1892), Voigt, Simpson of Calcutta (1892), and others have succeeded in cultivating a stock of virus which afforded perfect protection from subsequent inoculations of variolous matter. It may be stated, then, in summing up our present knowledge, that while vaccinia is very probably variola modified in some mysterious manner by its passage through the system of the cow, the difficulties of inoculation and the sad results which attend the use of spurious virus render bovine variolation impracticable as a source of vaccine supply. It is but right to add, however, that the experiments of Dr. Voigt,[2] Superintendent of the Vaccine Institute of Hamburg, lead to a different conclusion. He has experimentally demonstrated that where bovine variolation is practised the product of the first inoculation retains nearly all of the virulence of the original seed, but by successive transmissions from one animal to another it is so modified and reduced in activity as to correspond perfectly in its effects upon the human economy with lymph obtained from spontaneous cowpox. According to Voigt, true smallpox virus must be passed through not less than six heifers before it becomes properly transmuted and safe for human vaccination. The undue violence, both local and constitutional, induced not only by original cowpox virus, but by the earlier human removes from it, seems to offer some confirmation of the above statement. This theory is also strongly supported by the more recent researches of King, of Madras, Hime, of England, and of Haccius and Éternod, of Switzerland (1892). The latter deduce as one of their conclusions: "Smallpox inoculated in the heifer becomes transformed into vaccine in the course of several generations by transmission through the animal."

W. J. Conklin.

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[1] The Medical News, vol. xl., p. 498.

[2] The Medical Times and Gazette, September, 1882.

COXA VARA.—(Synonym: Incurvation or depression of the neck of the femur.)

In the normal femur the neck projects slightly forward, and upward to form an angle of about 125° with the shaft. In childhood this angle is generally somewhat greater, and in later years it may be somewhat less than this; in fact, a variation between 110° and 140° may be within the normal limit.

When the neck of the femur is depressed to a degree that causes disability, the affection is called coxa vara. Coxa vara, like genu varum and genu valgum, is one of the group of so-called static deformities of the lower extremity, that more often appear at two periods of life: in early childhood, as a direct result of rhachitis; and in adolescence, when, with the weakness and the increased weight incident to this period of rapid growth, is combined, in many instances, the strain of laborious occupation (Fig. 1528).

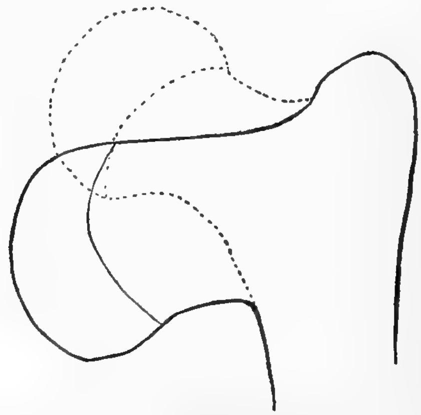

FIG. 1528.—Outline of the Depressed Neck of the Femur in Müller's Specimen, Contrasted with the Normal Position shown by the Dotted Line.

Genu varum and valgum are common in childhood, but rarely develop in adolescence; coxa vara, in comparison, is not only an infrequent deformity, but it differs also in that it more often attracts attention in later childhood or adolescence than at an earlier period, doubtless because the neck of the femur is, at the age when rhachitic distortions are common, very short and is relatively stronger than the shaft, while in adolescence the conditions may be reversed. The distortions at the knee are self-evident, but the neck of the femur is concealed from view so that the diagnosis of its depression may be somewhat difficult, and, in fact, it is only in very recent years that its symptoms have been recognized.

Fiorani first described the deformity as it had been observed by him in childhood (*Gazetta degli Ospitali*, Nos. 16, 17, 1881), but E. Müller first called attention to the affection as one of the deformities of adolescence which, until that time, had been mistaken for hip disease (*Beiträge zur klin. Chir.*, 1889, Bd. iv.).

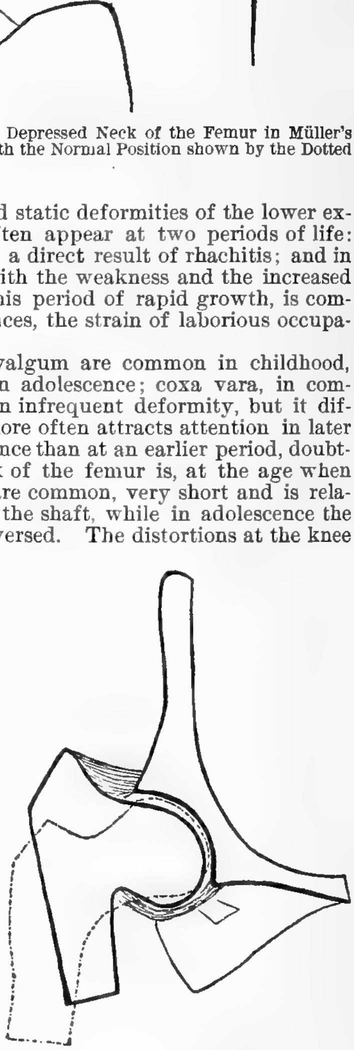

FIG. 1529.—Cross Section of the Pelvis and the Deformed Femur. A scheme to show the effect of the deformity in limiting abduction of the limb. The dotted outline shows the normal relation.

PHYSICAL SIGNS AND SYMPTOMS.—The nature of the symptoms is explained by the physical effects of the deformity. The neck of the femur is depressed, and it is usually twisted somewhat backward in its relation to the shaft, following the line of least resistance. Thus the limb is actually shortened and is rotated outward; the trochanter is elevated above Nélaton's line, its prominence is increased, and it is displaced somewhat forward toward the anterior superior spine in compensation for the loss of the normal forward projection of its neck.

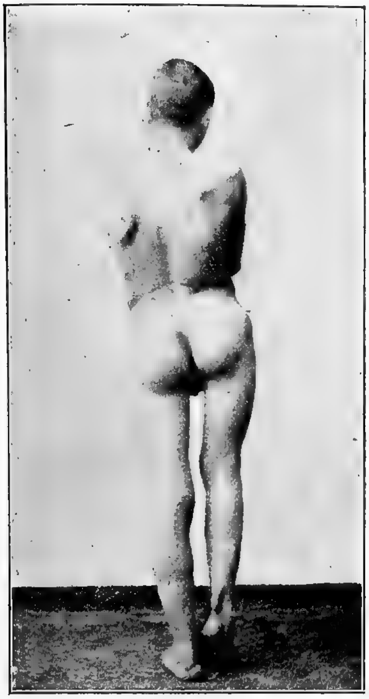

FIG. 1530.—Unilateral Coxa Vara of an Extreme Degree. Showing great apparent shortening due to the adduction of the limb.

A secondary effect of the distortion is limitation of the normal range of motion. Abduction is checked by the tension upon the lower border of the capsule, by the adaptive shortening of the adductor muscles, and by the direct contact of the neck of the femur with the upper border of the acetabulum (Fig. 1529). Inward rotation and flexion are limited because of the backward displacement of the neck, but the range of extension is not restricted and it may be increased even.

In rare instances the depression of the neck of the femur may be directly downward, in which case the range of motion is but little affected except in abduction; or the distortion may be downward and forward, when extension and outward rotation are limited in the place of flexion and inward rotation. These cases are, however, exceptional, and they are practically never seen in the adolescent type of deformity.

The most noticeable symptom of coxa vara is a persistent limp, due primarily to the shortening of the limb caused by the depression of the neck of the femur. The actual shortening, which is not often more than an inch, is, in well-marked cases, increased by an upward tilting of the pelvis on the affected side, in compensation for the restriction of abduction, similar to the so-called practical shortening of hip disease. This practical shortening may be from one to three inches (Fig. 1530). Thus, as in genu varum and genu valgum, the direct effects of the deformity are the most characteristic symptoms, although in coxa vara there is usually greater discomfort than in the latter affections, because the interference with the function of the joint is more marked. The patient usually complains of sensations of weakness and discomfort after long standing or walking, and of stiffness on changing from a position of rest to one of activity. This discomfort, usually referred to the thigh and the neighborhood of the joint, may be increased to actual pain by overexertion or injury; in such instances there may be attendant muscular spasm which disappears with the subsidence of the acute symptoms.

DIAGNOSIS.—On physical examination, the shortening is apparent and its cause is explained by the elevation of the trochanter. There is the characteristic limitation of motion that has been described, but as a rule pain on manipulation and muscular spasm are absent. There are slight atrophy, more marked in the thigh than in the leg, and in most cases persistent outward rotation of the limb also is present.

There are but three affections with which coxa vara is likely to be confounded. These are:

1. Fracture of the neck of the femur.
2. Congenital dislocation of the hip.
3. Hip disease.

1. *Impacted fracture of the neck of the femur*, or simple united fracture, causes deformity practically identical with coxa vara. It must therefore be distinguished from it by the history of injury and subsequent disability.

2. *Congenital dislocation of the hip* is a disability that is apparent when the child begins to walk, while coxa vara does not, except in very rare instances, develop until a later period. In congenital dislocation the head and neck of the bone may be palpated beneath the gluteal muscles when the thigh is flexed and adducted, while in coxa vara only the prominent trochanter can be felt. There is also an absence of the abnormal mobility that characterizes the former affection.

3. *Hip Disease.*—In hip disease there are discomfort on manipulation, muscular spasm, and limitation of motion in all directions; while in coxa vara muscular spasm is usually absent and the limitation of motion is irregular. In hip disease shortening is a late symptom, in coxa vara it is present from the first; and finally, in hip disease there is usually some evidence of the local destructive process, in swelling, sensitiveness, and the like, symptoms that are of course absent in coxa vara.

BILATERAL COXA VARA.—Bilateral coxa vara is far less common than the unilateral form. The limp is replaced by a waddle or swaying of the body from side to side, resembling the gait of knock-knees. The awkwardness and weakness are of course correspondingly increased, and in the extreme cases, in which the thighs are adducted, the limbs may be crossed so that walking is extremely difficult. The pelvis appears to be abnormally broad because of the elevated and prominent trochanters, and the lumbar lordosis is diminished (Fig. 1531) because of the loss of the normal inclination of the pelvis due to the forward displacement of the supporting femora. In the rare cases in which the femoral necks are displaced forward as well as downward, the lumbar lordosis is increased and the appearances are somewhat similar to those of congenital dislocation of the hips (Fig. 1532). Bilateral coxa vara is not

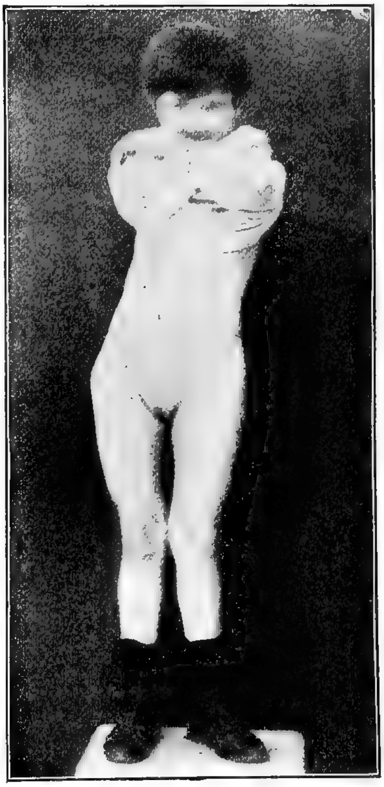

FIG. 1531.—Bilateral Coxa Vara, more Marked on the Right Side. Complete loss of abduction on both sides.

infrequently accompanied by other evidences of weakness, for example by knock-knees or by flat feet.

STATISTICS.—About 75 per cent. of the cases of coxa vara are in males, and in a similar proportion of cases the affection is unilateral. In 42 cases treated by the writer, the first symptoms were noted in adolescence (twelve to seventeen years of age) in 22. In later childhood (five to eleven years of age) in 14; in early childhood (less than five years) in 5; unknown, 1. In 37 instances the neck of the femur was depressed downward and backward, in 3 downward and forward, in 2 directly downward. The deformity was unilateral in 35, bilateral in 7 cases. Thirty-one of the patients were males, 11 were females.

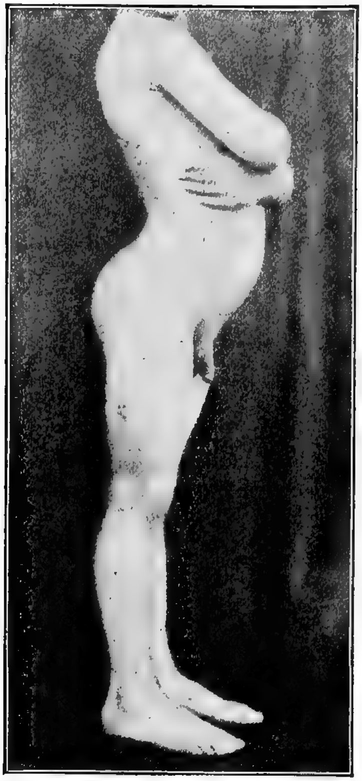

FIG. 1532.—Bilateral Coxa Vara, of the Anterior Form, Showing the Lordosis. An uncommon type that resembles congenital dislocation of the hips.

ETIOLOGY. — It is evident that depression of the neck of the femur may be caused by local disease, such as tuberculosis, infectious osteomyelitis, rheumatoid arthritis, and the like. Deformity from such causes should be classified, however, as incidental to the disease of which it is a result, while the term coxa vara should be reserved for those cases of simple deformity which are caused by local weakness rather than by actual disease. The physical signs of unilateral coxa vara are, as has been stated, practically identical with those of impacted fracture of the neck of the femur, and in childhood, but for the history of injury and of the immediate disability that followed it, it would be impossible to distinguish between the two. Fracture of the neck of the femur is, as the writer has demonstrated, comparatively common in childhood, and for practical purposes it may be classified as the traumatic form of coxa vara.

The Etiology of Simple Coxa Vara.—In very many instances coxa vara may be explained by an acquired or an inherited predisposition to the deformity. The normal inclination of the neck of the femur protects it from strain; if the angle is diminished the strain upon the part is proportionately increased. This is proved by the fact that simple traumatic depression predisposes to further deformity long after the repair of the injury. Thus, one may assume that in many instances a slight depression is acquired in childhood as a result of rhachitis, of which there was a clear history in more than a third of the cases examined by the writer, including all of the bilateral form. Such depression may remain latent, or under favoring circumstances it may become exaggerated to noticeable deformity. These favoring circumstances are, as has been stated, more likely to occur during adolescence, when to the instability of rapid growth is added the increase of the weight of the body, and in some instances the over-strain of laborious occupation.

In other instances there may be a congenital predisposition to the deformity, caused either by a lessened angle or by abnormal weakness of structure, and one case of congenital coxa vara has been reported by Kredel (*Cent. für Chir.*, October 17th, 1896). In none of the cases in later childhood or adolescence examined by the writer has there been evidence of active or "late" rickets, and the presence of so-called local rickets, as accounting for the deformity, is at present unproved.

In a small percentage of the cases the early symptoms appear to have been induced or aggravated by over-strain or injury, but as a rule the symptoms appear insidiously and without assignable cause.

PATHOLOGY.—In ordinary cases the neck of the femur is depressed to a right angle with the shaft, but in certain instances the deformity may be greater. Usually the entire neck is involved in the distortion. Less often the deformity is greatest at the epiphyseal junction.

In the specimens that have been examined during the progressive stage, the internal structure has shown congestion and softening, changes that would almost inevitably appear in a bone bending and breaking under strain, but no other evidences of disease have appeared that would justify a diagnosis of so-called local rickets or osteomalacia. As has been stated, coxa vara may occur in early childhood as one of the distortions of rhachitis; but in the adolescent type of deformity, evidence of general weakness of this character is unusual.

PROGNOSIS.—In the adolescent type of coxa vara the duration of what may be termed the active stage of the affection is from one to three years. The deformity then ceases to progress, the symptoms of discomfort disappear, the restriction of motion becomes less marked and the disability less noticeable.

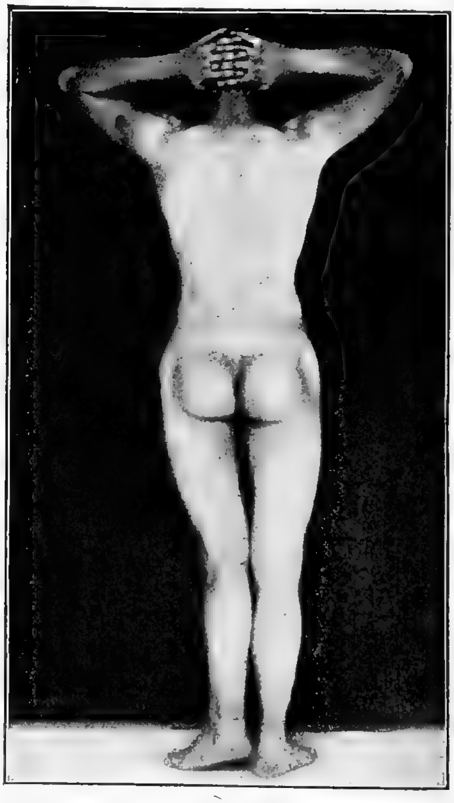

FIG. 1533.—Unilateral Coxa Vara of the Ordinary Form. A final result. The elevated and prominent trochanter, the shortening, and the outward rotation are shown.

In the unilateral form a moderate limp remains, and in the bilateral type a degree of disability and awkwardness, in proportion to the final restriction of the range of abduction. If the affection first appears in childhood, the progress of the deformity is slower, and it is often intermittent, increasing usually during adolescence. In this regard the affection resembles closely other distortions of similar origin (Fig. 1533).

Treatment.—Deformity of the neck of the femur cannot be remedied by braces. The part can be relieved, however, from strain by restricting the burden of occupation, and distortion may be checked by the use of a support, similar to that employed in the treatment of hip disease, by which the weight is borne upon the perineum.

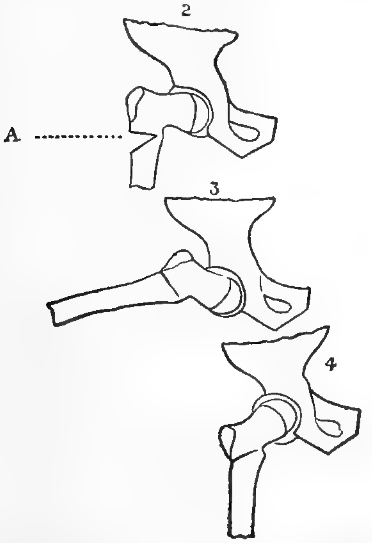

Fig. 1534.—1, The Normal Femur; 2, depression of the neck of the femur—coxa vara (at A a wedge of bone has been removed); 3, abduction of the limb first fixes the upper segment by contact with the rim of the acetabulum, then closes the opening in the bone; 4, replacement of the limb after union is completed elevates the neck to its former position.

Massage and exercises to improve the nutrition of the part, and manipulation with the aim of overcoming restriction of motion, may be of service also, and general therapeutic treatment may be indicated in suitable cases.

As a rule, however, the most effective treatment is the correction of the depression by operation. This is indicated as a prophylactic measure in the younger class, in which the deformity is slight. For as the depression of the neck of the femur increases, the strain upon it is greater and thus there is a tendency to progressive deformity, which one may hope to check by replacing the neck at its normal angle. This may be accomplished by the removal of a sufficient wedge of bone from the base of the trochanter. In this operation all resistance to abduction, other than that dependent upon the deformity of the bone, should be overcome by preliminary manipulation. The base of the wedge, about three-quarters of an inch in width, should be directly opposite the trochanter minor. The layer of cortical substance on the inner aspect of the bone should not be divided, but should serve to retain the two segments of the femur in proper relation to one another. When the wedge has been removed, the thigh should be gently abducted; the upper fragment is first fixed by contact with the acetabulum and the shaft is then bent outward upon it until the opening is closed by apposition. In this attitude of extreme abduction the limb is fixed by a plaster bandage. When union is complete, the neck of the femur is replaced in its normal relation to the shaft when the limb is in the normal attitude. As a rule, no apparatus is required in the after-treatment (Fig. 1534).

In the adolescent cases it is well to postpone the operation until a certain stability of tissue is assured, and in certain instances, particularly those in which there is marked antero-posterior distortion of the neck, a simple linear osteotomy may be indicated, as the distortion may be corrected by rotating the shaft on its long axis until the foot is brought to its normal position.

Royal Whitman.

LITERATURE.

The more important articles on this subject, besides those mentioned in the text, are as follows:
Hofmeister: Beiträge zur klin. Chir., Bd. xxi., H. 2, 1894.
Whitman: N. Y. Med. Jour., June 23d, 1894, January 21st, 1899, and Annals of Surgery, February, 1900.
Frazier: Annals of Surgery, July, 1898.
Alsberg: Zeit. f. orthop. Chir., Bd. vi., H. i., 1898.

CRAB-ORCHARD SPRINGS.—Lincoln County, Kentucky.

Access.—Viâ Knoxville Branch of the Louisville and Nashville Railroad to Crab Orchard, 115 miles southeast of Louisville.

These waters are chiefly used in the manufacture of the famous Crab Orchard salts, which are used extensively in Kentucky and neighboring States as a cathartic. The following analyses were made by Dr. Robert Peter, State Geologist:

One United States Gallon Contains:

Solids.	Epsom or Foley Spring, grains.	Sowder's Spring, grains.
Magnesium carbonate	7.64	19.20
Iron carbonate	Trace.	Trace.
Calcium carbonate	53.18	29.51
Sodium chloride	17.72	58.32
Potassium sulphate	9.91	17.37
Sodium sulphate	59.07	23.20
Magnesium sulphate	205.28	174.31
Calcium sulphate	10.79	91.32
Bromine	......	Trace.
Silica	3.26	1.22
Loss and moisture	34.58	Trace.
Total	401.43	414.45

Carbonic acid not estimated.

Crab-Orchard Salts.

100 Parts Contain:	Parts.
Magnesium sulphate	63.19
Sodium sulphate	4.20
Potassium sulphate	1.80
Calcium sulphate	2.54
Sodium chloride	4.77
Lime, magnesia, iron and silica (carbonates)	.89
Bromine	Trace.
Water of crystallization and loss	22.61
Total	100.00

Other springs at Crab Orchard are the "Field" and the "Grove" springs, which are but feebly impregnated with mineral ingredients. *James K. Crook.*

CRAMP BARK. See *Viburnum Opulus.*

CRAMPS.—Cramp is a term applied to denote a painful tonic muscular contraction of some moments' or minutes' duration. As several of these painful contractions generally occur successively, the term "cramps" is used to designate the attack. Cramps belong to the local spasmodic disorders; cramp is, in fact, technically a local tonic spasm, to which is added the element of pain. It is true that in tetanus there is a general cramp of almost the entire voluntary muscular system, and that in cholera cramps are widely diffused; nevertheless medical usage assigns the term cramps to the local spasmodic disorders.

Properly speaking, cramps may affect both the voluntary and the involuntary muscles. Writers sometimes speak of cramps of the heart, of the stomach, intestines, bladder, and uterus; but, as a rule, these cramps of the involuntary muscles are given the term colic. Cramps of the voluntary muscles are strictly analogous, therefore, to colic of the involuntary muscles.

The further relations of cramps to the other hyperkineses are shown in the article on *Convulsions*. In this description of cramps we shall limit the application of the term, as is usually done, to the voluntary muscles.

Clinical History.—The voluntary muscles oftenest affected by cramps are those of the extremities, and especially those of the lower extremities. The muscles most susceptible are the gastrocnemii and plantar muscles. The psoas muscle, and flexors of the thigh upon the abdomen, are also at times affected. In the upper extremities it is the muscles of the fingers that are most often attacked. In the special neurosis of which writer's cramp is a type, the muscles of the whole arm may also be involved. Of the trunk muscles, those forming the soft wall of the abdomen are not infrequently affected with slight cramps. After a violent sneeze, for example, part of the rectus may become knotted up in a cramp. In cholera the abdominal muscles are all involved. A sudden "stitch in the side," is due to a cramp of some of the intercostal muscles. A crampy condition of the sterno-cleido-mastoid and of part of the trapezius is observed in the clonic forms of wry-neck. The muscles of the face, of the eye, and of mastication, are not subject to cramps, except in very rare cases.

When the term cramp is used, without further special designation, it refers to painful spasms in the extremities, especially the lower extremities. Attacks of such spasms come on generally at night, or after some violent exertion, such especially as swimming, when the circulation in the extremities is disturbed by the cold water. The pain and contraction come on suddenly, as a rule, though sometimes slight premonitory twinges are felt. The muscle is contracted, and feels hard and knotty, the limb is drawn up, and attempts to straighten it or to relax the muscle give great pain. The patient often feels a sensation of nausea, depression, and even of faintness. Pressure on the affected part gives relief, and forcible rubbing or sudden extension of the muscle will often relax the spasm. No especial change in the electrical relations has been observed. The attack lasts only a few seconds or minutes, as a rule, but it may continue for hours. After one attack has gone, a second and third may succeed. A patient may have to get up half a dozen times a night on account of his seizures.

When the spasms have disappeared, the muscle is left sore and tender to the touch, owing to stretching of the muscle and the irritation and injury to the sensory nerves.

Etiology.—Cramps in the extremities occur as the result of organic disease of the brain and spinal cord, and as the result of certain functional morbid conditions. Pressure on, or irritation of, nerve trunks sometimes causes cramps. The cramps of organic disease I do not purpose to consider here. The causes of the functional cramps are various. In some persons there is an inherited or connate tendency to this trouble. Cramps occur more frequently in the aged and in growing children than at the middle period of life. Gouty and rheumatic conditions, and anæmia, predispose persons to them. In disordered states of the stomach and bowels nocturnal attacks of cramp occur. Cramps in the lower extremities are often an annoying disturbance of pregnancy. In the early months the gastrocnemii and plantar muscles are most affected; later the thighs are drawn up by painful contractions of the psoas and other flexors. These cramps of pregnancy are probably at first reflex in character; later they are due to the pressure of the gravid womb on the nerves which supply the lower limbs.

Cramps of a distressing character occur in Asiatic cholera and cholera nostras. They are also observed in persons of intemperate habits. Arterial sclerosis involving the vascular supply of the legs is a cause of leg cramps of elderly people.

Probably the most frequent of all the exciting causes of ordinary forms of cramps in the extremities is violent exercise, such as swimming, dancing, walking, running, and jumping.

Pathology.—In the ordinary type of cramps the muscle itself is at fault. Through deficient nutrition or over-use its fibres are irritated, an involuntary contraction results which is painful because it is so abnormally powerful that the sensory nerve fibres are pressed upon. Tonic spasms become painful and crampy in character, therefore, simply because of a quantitative excess in muscular contraction. No one can voluntarily knot up his calf muscles as is done in a cramp. The myopathic character of the contraction is shown by the fact that, by the pressure of bands and tourniquets, which alters the blood supply to the muscles, the cramps can often be relieved.

There are, however, certain forms of cramps, like wry-neck, or writer's cramp, that are of purely nervous origin. Here the cramp is due to overstimulation.

Treatment.—The treatment of the ordinary type of leg cramps must be addressed first to the general condition. Rheumatic, gouty, and anæmic tendencies must be corrected, dyspepsia and constipation relieved. If the attacks are unusually severe and obstinate, the question of diabetes or of some organic disease must be investigated. A number of devices have been recommended for preventing the attacks. Among these, one which I have found successful is tying a tape about each thigh just above the knee. This is done just before retiring. Raising the head of the bed by placing one or two bricks under the posts is a measure which I have not found to do any good. A dose of bromide with alkalies at night, or a mixture containing gr. v. each of lupulin and camphor, may be given. In severe cases, especially in pregnancy, codeine or opium may be added to these. Massage and faradization of the limbs will sometimes ward off attacks, and so will small doses of strychnine continuously administered.

When the attack comes on, the affected muscles must be vigorously rubbed and kneaded. If the patient jumps up at once and puts the muscles on the stretch, he can often break up the cramp. A little rubbing and exercise will then quiet the muscle. *Charles L. Dana.*

CRANIAL NERVES.—The Doctrine of Nerve Components.—The proper classification and morphological comprehension of the cranial nerves, human and comparative, have remained in an unsatisfactory state because of the difficulty of correlating the several anatomical and physiological data with each other and with the findings of the embryologists. That the arrangement and composition of the twelve pairs of cranial nerves as commonly enumerated have a profound morphological significance is evident from the remarkable constancy with which their main features are repeated throughout the vertebrate phylum. But we are still very far from a complete explanation of the individual peculiarities of the several pairs, and especially of the differences between the cranial and the spinal nerves. During the past decade, however, this field has been very diligently cultivated by the comparative anatomists and much progress has been made toward a better comprehension of the significance of the peripheral nervous system as a whole.

Starting from the undifferentiated nerve tube of the ancestral vertebrate or of the embryo, the morphologist who follows the series of forms presented by the central nervous systems of the animal types from Amphioxus to man will find the problems suggested by this progressively increasing complexity soluble largely in proportion as he realizes that every change in the centre is but the reflection of a corresponding change in the peripheral nervous system, especially the sense organs, which in turn rests upon a new point of contact with the outside environment.

This point of view—the correlation of changes in the centre with those in the periphery—lies at the basis of the recent work on nerve components. To Gaskell belongs the credit of having clearly separated the peripheral nervous system into two great categories: on the one hand, the visceral systems, sensory and motor, which effect the adjustments to the internal environment; and on the other hand, the somatic systems, sensory and motor, which effect the adjustments to the external environment. With this as a foundation to build upon,

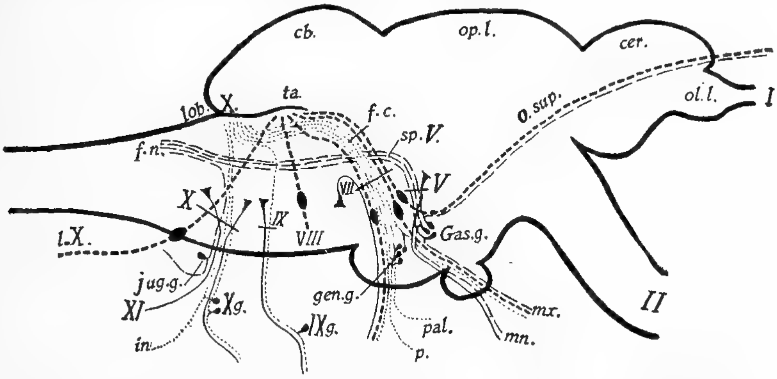

FIG. 1535.—The Cranial Nerves of *Menidia* as seen from the right side, illustrating the central convergence of the sensory components of the several nerves into functional systems. The eye-muscle nerves have been omitted, the superficial origins of the others being indicated by the Roman numerals at the transverse lines drawn across their roots. The viscero-motor roots are drawn as continuous lines, the general cutaneous roots as broken lines, the acustico-lateral system as heavier broken lines, and the communis system (visceral sensory) as dotted lines. The positions of the auditory and of the four lateral line ganglia are indicated, though no special designations are given them. This scheme can be applied with but slight modification to all of the fishes. The student of comparative anatomy will notice that some rami peculiar to the teleosts have been omitted, *e.g.*, the r. lateralis accessorius and the general cutaneous fibres in the hyomandibular trunk. Compare the detailed plot from which this diagram is drawn off, *Journal of Comp. Neurology*, vol. ix., plate xvi., and *Archives of Neurology and Psychopathology*, vol. ii., plate iii. The scheme can be adapted to higher vertebrates (including man) by the suppression of the lateral line roots of the facialis and vagus, leaving the VIII. nerve as the only representative of the acustico-lateral system.

cb., Cerebellum; *cer.*, cerebrum; *f.c.*, fasciculus communis (=fasc. solitarius); *f.n.*, funicular nucleus (terminal nucleus of spinal V. tract); *Gas.g.*, Gasserian ganglion; *gen.g.*, geniculate ganglion; *in.*, ramus intestinalis vagi; *IX.g.*, glossopharyngeal ganglion; *jug.g.*, jugular (gen. cutaneous) ganglion of the vagus; *lob.X.*, lobus vagi (sensory vagus nucleus); *l.X.*, ramus lateralis vagi; *mn.*, ramus mandibularis V; *mx.*, ramus maxillaris V; *ol.l.*, olfactory lobe; *op.l.*, optic lobe; *o.sup.*, superficial ophthalmic branches of the VII. and V. nerves (the latter = frontal nerve of man); *p.*, pretrematic branch of the facialis, corresponding in position with the chorda tympani of man, though not strictly homologous with it; *pal.*, ramus palatinus VII. (= great superficial petrosal); *sp.V.*, spinal V. tract; *ta.*, tuberculum acusticum (terminal nucleus for acustico-lateral system); *thm.*, hyomandibular trunk (= great facial trunk of man); *Xg.*, chief vagus ganglion; *XI.*, motor fibres for trapezius muscle, supposed to represent the accessory nerve.

Strong carried out the separation of these elements, especially the sensory ones of the cranial nerves, into other components.

Undoubtedly the morphological unit of structure in the peripheral, as in the central, nervous system is the neuromere, or neural segment. This is clearly seen in the peripheral (though not in the central) nervous system in the trunk region of the adult body, each spinal nerve repeating in a metameric way the morphological plan of its predecessors. Both embryology and comparative anatomy show that the head was also primitively segmented, and the present arrangement of the cranial nerves of man undoubtedly has a metameric basis; nevertheless so many disturbing factors have entered that it has thus far been impossible to determine what was the original segmentation of the head in general or of the cranial nerves in particular, so that it is not yet practicable to base a classification of the nerves upon this feature. On the other hand, the numerical designations of Sömmering now generally employed have little significance other than mere convenience in topographical description.

A descriptive unit which is much more generally useful is the functional *system.* Such a system has clearly definable morphological characters, easily demonstrable in the adult, and is immeasurably more useful in clinical neurology, and indeed in all pathological work. Each system may be defined as the sum of all the nerve fibres in the body, which possess certain physiological and morphological characters in common, so that they may react in a common mode. Morphologically, each system is defined by the terminal relations of its fibres—by the organs to which they are related peripherally and by the centres in which the fibres arise or terminate. The fibres of a single system may appear in a large number of nerves, repeated more or less uniformly in a metameric way (as in the general cutaneous system of the spinal nerves), or they may all be concentrated into a single nerve (as in the optic nerve). On the other hand, a single nerve may contain several components, *i.e.*, its fibres may belong to several of these systems. It becomes necessary, therefore, to analyze the root complex of each pair of cranial nerves into its components and to trace not only the central connections of these components within the brain, but also their peripheral courses as well. In other words, the description of any given nervous ramus is not complete when we have given its point of origin from the nerve trunk or ganglion, the details of its devious courses, and the exact points where the several ramuli terminate. In addition to this it is necessary to learn what systems are represented in the ramus, and the precise central and peripheral relations of each system.

The difficulty in determining this latter point is the chief obstacle in the way of researches on the nerve components; for, while the central connections of any nerve can be determined by the microscopical method, the peripheral courses are usually studied by gross methods which reveal nothing of the precise relations of the several components peripherally, and hence do not permit a knowledge of each system as a whole. To trace the components of the more complex cranial nerves continuously from their nuclei of origin or termination within the brain by means of serial sections to their ultimate peripheral termini has never been attempted in the human body. In a few of the lower vertebrates, however,

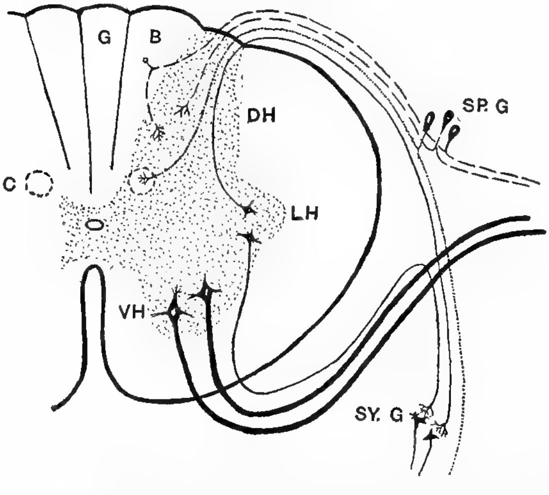

FIG. 1536.—Diagram illustrating the Composition of the Typical Spinal Nerve. The general cutaneous system is represented by broken lines, the visceral sensory by dotted lines, the somatic motor by the heavy continuous lines, the visceral motor by the lighter continuous lines. The visceral motor fibres of the dorsal root are found in lower vertebrates; their presence in the mammals is controverted.

B, Column of Burdach; *C*, Clarke's column; *DH*, dorsal horn; *G*, column of Goll; *LH*, lateral horn; *SP.G*, spinal ganglion; *SY.G*, sympathetic ganglion; *VH*, ventral horn.

this has been accomplished with a fair measure of success. All of the types thus far studied in this way exhibit certain broad general resemblances and permit the establishment of a schematic type of cranial nerve components which is presumably applicable to the vertebrates as a whole. From anatomical, physiological, and clinical data already in hand it is possible to compare the human nerves with this scheme and to infer the composition of most of the peripheral rami with more or less of accuracy.

The composition of the cranial nerves has been most fully worked out by Strong in the tadpole of the frog and by the present writer in the small marine fish called "silver sides" (*Menidia*) and in the codfish. Other notable contributions to the doctrine of the components have been made by Cole, Allis, Kingsbury, Ewart, Pollard, Shore, Gaskell, and others. The accompanying diagram (Fig. 1535) expresses the relations of the components as found in Menidia.

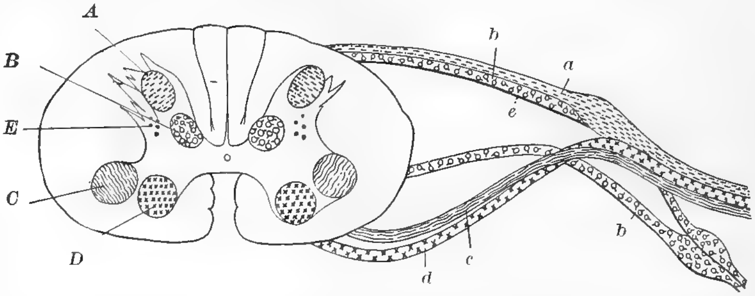

FIG. 1538.—Cross-section of Spinal Cord to Illustrate Gaskell's Views. (Hans Gadow.) *A*, cells of dorsal horn; *B*, cells of Clarke's column; *C*, cells of lateral horn; *D*, cells of ventral horn; *E*, solitary cells at base of dorsal horn; *a*, somatic afferent fibres; *b*, splanchnic ganglionated efferent fibres; *c*, splanchnic non-ganglionated efferent fibres for visceral and enteric muscles; *d*, somatic efferent fibres; *e*, splanchnic afferent fibres.

Following Gaskell and His, we now recognize four systems of components (see Fig. 1536) in the spinal nerves, two motor and two sensory: 1. Somatic motor fibres, arising from cells of the ventral horn and forming the major part of the ventral root, to supply the somatic musculature. 2. Visceral motor fibres, arising from cells in the region of the lateral horn and emerging with the ventral root and (in lower vertebrates, at least) also with the dorsal root. They innervate the visceral or splanchnic musculature via the sympathetic system, forming the preganglionic fibres of Langley. 3. General cutaneous fibres, arising from cells of the spinal ganglia and forming the greater part of the dorsal root fibres. They comprise the somatic sensory fibres of Gaskell, excluding, however, fibres to special cutaneous sense organs of all kinds. 4. Visceral sensory fibres, arising from cells of the spinal ganglia, entering the spinal cord through the dorsal root to terminate probably in Clarke's column and distributing peripherally to visceral surfaces through the sympathetic system. The number of fibres of this system in most of the spinal nerves is probably small, the visceral sensory function having been largely supplanted by the visceral branches of the vagus. Whether any visceral sensory fibres arise from cells in the sympathetic ganglia is a disputed point.

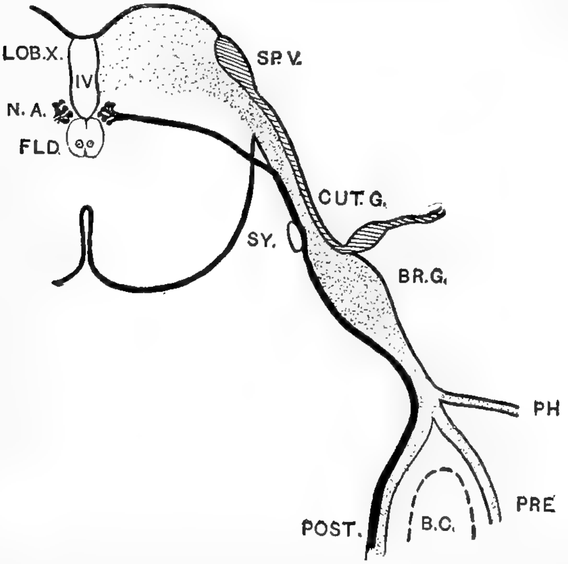

FIG. 1537.—Diagram of a Typical Branchiomeric Nerve among the Fishes. The viscero-motor component is drawn in black, the general cutaneous cross-hatched and the visceral sensory stippled. *B.C.*, Branchial cleft; *BR.G.*, branchial ganglion; *CUT.G.*, general cutaneous ganglion; *FLD.*, fasciculus longitudinalis medialis; *IV.*, fourth ventricle; *N.A.*, nucleus ambiguus, the nucleus of origin of the motor fibres; *LOB.X.*, lobus vagi, the terminal nucleus of the visceral sensory fibres; *PH.*, ramus pharyngeus; *POST.* post-trematic ramus; *PRE*, pre-trematic ramus; *SP.V.*, spinal V. tract, associated with the terminal nucleus of the general cutaneous fibres; *SY.*, sympathetic ganglion.

Each of the spinal nerves typically contains some fibres of each of these four systems; but the relations in the head are complicated by the reduction of some components and the great exaggeration of others, as well as by the introduction of entirely new systems. The somatic motor system is represented in the hypoglossus and the eye-muscle nerves; the motor nuclei of the XI., X., IX., VII., and V. pairs are commonly relegated to the visceromotor system; the general cutaneous system is represented in the vagus, trigeminus, and according to some authorities in the glossopharyngeus, and the visceral sensory system corresponds to what we have termed in the lower vertebrates the *communis system*—*i.e.*, sensory nerves related to the fasciculus communis (= fasc. solitarius) and its associated terminal nuclei, viz., the visceral sensory portion of the vagus, the lingual branch of the glossopharyngeus, and the portio intermedia of the facialis. Associated with the general visceral fibres of these latter nerves are others of a special sensory nature innervating the taste buds. It is not at present possible to differentiate these two types of fibres centrally and they are both included under the designation "communis system." Presumably the special sensory fibres have been derived from the general visceral system in correlation with the differentiation of the special sense organs of the mouth.

With the advancing specialization of the head in vertebrates, the motor systems of this region (especially the segments in front of the gills) have been either reduced or devoted to special functions, and the unspecialized sensory systems of the trunk are largely replaced by nerves of special sense, such as those of the ear, eye, and nose. The increasing relative importance of the sensory nerves as compared with the motor, as we pass cephalad, is illustrated by figures given by Donaldson. Thus, the ratio of motor to sensory fibres entering the spinal cord is estimated as 1:1.6, while the ratio of motor to sensory fibres in the cranial nerves taken as a whole is 1:30. From the point of view of composition, the nerves of the body may be divided into four types, as follows:

1. The spinal type. Its characters are given above. The hypoglossus is the only cranial nerve belonging here. In some of the fishes this is a typical spinal nerve in all respects save that it sends some fibres of its ventral ramus forward into the hyoid (tongue) musculature. In man all the nerve except these latter fibres has disappeared.

2. The branchiomeric type. The nerves of this type in the fishes supply the gill arches and their derivatives, the hyoidean and mandibular arches, comprising the X.,

TABLE OF NERVE COMPONENTS.

System.	Function.	Nerve roots.	Primary nuclei.	Chief secondary connections.	Ganglia.	Chief rami.
I. Somatic motor.	Motor (somatic or skeletal musculature).	1. Ventral spinals..	Ventral horns	Reflex paths from sensory spinal centres; motor zone of cortex via direct and crossed pyramids.	....	Dorsal and ventral rami of spinal nerves.
		2. XII. nerve......	XII. nucleus..........	Reflex paths from sensory cranial nuclei (?) from superior olive and from cortex via pyramids and tract of Hoche in medial fillet.	....	Rami to tongue musculature (speech mechanism).
		3. VI. nerve .... 4. IV. nerve....... 5. III. nerve.......	VI. nucleus......... IV. do. .... III. do.	Reflex paths from sensory cranial nuclei and from superior olive; from pregeminum and from spinal centres via fasc. long. medialis; from cortex via pyramids.	....	Rami for the extrinsic and intrinsic eye muscles.
II. Viscero-motor.	Motor (visceral musculature).	1. Ventral and dorsal spinals.	Lateral horns.........	Reflex paths from sensory spinal centres (?) collaterals from pyramids (?).	....	Preganglionic nerves, rami communicantes to sympathetic ganglia, possibly also to sporadic ganglia via dorsal and ventral rami.
		2. XI. nerve	(a) Lateral horn...... (b) N. ambiguus ...	Do	....	Accessorius spinalis, for sterno-mastoid and trapezius muscles. Accessorius vagi, joins vagus trunk.
		3. X. nerve........	(a) Chief vagus n .. (b) N. ambiguus....	Reflex paths from sensory cranial nuclei; collaterals from the pyramidal tracts.	....	External laryngeal, inferior laryngeal, cardiac, œsophageal, gastric.
		4. IX. nerve...	N. ambiguus.........			Stylo-pharyngeus muscle.
		5. VII. nerve.......	VII. nucleus	From sensory V. root; corp. trapezoides (cochlear root); fundamental lateral column (lower sensory centres?); pyramidal tracts and tract of Hoche in medial fillet.	....	Stapedius muscle, auricular and scalp muscles, posterior belly of digastric, stylo-hyoid, superficial facial musculature.
		6. V. nerve	(a) Chief motor n., (b) mesencephalic n. and locus cœruleus.	Reflex paths from sensory cranial nuclei; collaterals from pyramidal tracts.	....	Temporal, masseter, external and internal pterygoid, tensor palati, tensor tympani, anterior belly of digastric and mylo-hyoid muscles.
III. General cutaneous.	General tactile sensibility.	1. Dorsal spinals...	Dorsal horns	(1) Dorsal columns, funicular nuclei, medial fillet to cerebral cortex and reflex centres of basal ganglia; (2) lateral fundamental columns to basal ganglia; (3) funicular nuclei to cerebellum via restiforme; (4) Gowers' tract to cerebellum.	1. Spinal ganglia	Dorsal and ventral rami of spinal nerves.
		2. General cutaneous root of X.n.	Substantia gelatinosa of spinal V. tract.	Collaterals of root fibres (of V.) and secondary fibres to all cranial motor nuclei and to cerebellum (?); sec. connections with cerebral cortex and reflex centres of basal ganglia via lateral fillet and to vermis cerebelli via restiforme.	2. Jugular ganglion of X.	Ramus auricularis vagi.
		3. General cutaneous root of IX. nerve (?).	do.		3. Jugular ganglion of IX. (?).	(?)
		4. Sensory V.......	Do. + chief sensory V. nucleus.		4. Gasserian ganglion.	R. ophthalmicus, r. maxillaris, r. mandibularis.
IV. Visceral sensory (including communis system).	Visceral reflexes, taste.	1. Dorsal spinals...	Clarke's column (?) ...	Obscure—possibly Flechsig's dorso-lateral cerebellar tract.	1. Spinal ganglia	Enter sympathetic through rami communicantes.
		2. Visceral sensory root of X.	Spinal nucleus (fasc. solitarius).	Reflex connections with cranial motor nuclei; cerebral cortex via lateral fillet; cerebellar vermis via restiforme.	2. Trunk ganglion of X. (ganglion nodosum).	Meningeal r., r. pharyngeus, internal laryngeal r., inferior laryngeal r., visceral rami.
		3. Visceral sensory root of IX.			3. Petrosal ganglion of IX.	Tympanic r., pharyngeal rami, lingual rami (gustatory, posterior one-third of tongue).
		4. Portio intermedia VII.			4. Geniculate ganglion.	Great superficial petrosal; sensory fibres in main facial trunk; anastomoses with the sympathetic; chorda tympani (mainly gustatory anterior two-thirds of tongue).
V. Acustico-lateral.	A. equilibrium (static sense).	VIII. vestibular, or median, or anterior (+ lateral line roots of VII. and X. nerves of lower vertebrates)	(a) medial (Schwalbe), (b) spinal or descending, (c) lateral (Deiters), (d) superior (Flechsig, v. Bechterew), probably also (e) ventral cochlear nucleus, (f) cerebellum and other adjacent nuclei.	(1) Cerebellum, (2) fasc. long. medialis for oculomotor nuclei and lower centres, (3) lateral fillet, (4) lateral vestibular bundle.	Vestibular ganglion (ganglion of Scarpa).	Vestibular rami.
	B. audition....	VIII. cochlear, or lateral or dorsal.	Ventral and dorsal cochlear nuclei, trapezoid body, superior olive, etc.	(1) Striæ acusticæ and trapezoid body, superior olive, nucleus of lateral fillet, postgeminum, geniculatum mediale, cerebral cortex; (2) cerebellum.	Spiral ganglion (ganglion of Corti).	Cochlear ramus.
VI. Optic.........	Vision.........	Optic nerve (?)	(a) Geniculatum externum, (b) pulvinar	Optic radiations to occipital cortex..................	(?). Represented in the retina.	
			(c) pregeminum	Reflex connections with lower centres, especially with nuclei of III., IV., and VI. nerves.		
VII. Olfactory....	Smell	Fila olfactoria	Mitral cells of olfactory bulb.	(1) Lateral olfactory striæ to olfactory lobe (collaterals) and cortex of the uncus; (2) medial olfactory striæ to area parolfactoria, trigonum olfactorium, gyrus subcallosus, gyrus fornicatus, hippocampus; (3) ental olfactory tract, to pars anterior of anterior commissure and gyrus hippocampi.	Specific olfactory cells of nasal mucous membrane.	Absent.

IX., VII., and V. pairs. In the mammals, the true gill arches having disappeared save for slight vestiges in the laryngeal region, the primitive characters of these nerves have been profoundly modified. The spinal accessory nerve is a complex, belonging in part to the first type and in part to the second. The composition of a typical branchial nerve of the bony fishes is illustrated by the accompanying diagram (Fig. 1537).

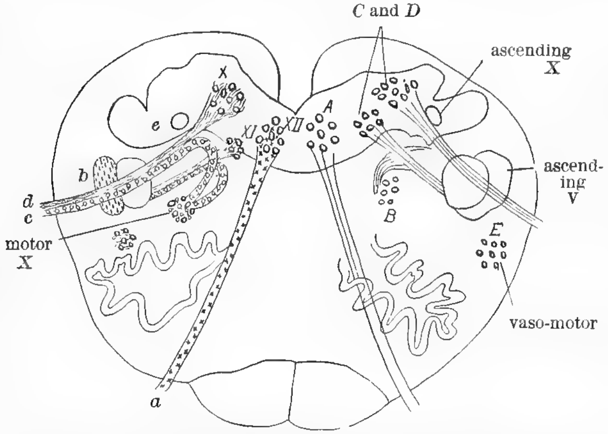

FIG. 1539. Schematic Cross-section of the Medulla Oblongata. (Gaskell.) *A*, cells corresponding to those of ventral horn; *B*, cells corresponding to those of lateral group of ventral horn; *C*, cells corresponding to those of Clarke's column; *D*, cells corresponding to the solitary cells at base of ventral horn; *E*, cells corresponding to those of lateral horn; *a*, somatic efferent fibres; *b*, somatic afferent fibres; *c*, splanchnic non-ganglionic efferent fibres; *d*, splanchnic ganglionated efferent fibres; *e*, splanchnic afferent fibres.

3. The oculomotor type. Illustrated by the VI., IV., and III. pairs, commonly regarded as somatic motor nerves.

4. Nerves of special sense. These comprise the olfactory, optic, and auditory nerves, and should doubtless include also the gustatory nerves (related to the fasciculus solitarius), though these latter, as stated above, cannot as yet be separated anatomically in their intracranial courses from the associated nerves of general visceral sensation.

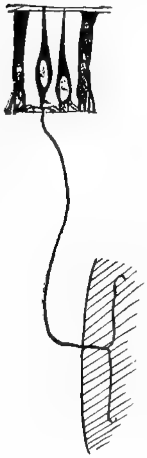

FIG. 1540.

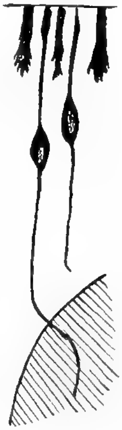

FIG. 1541.

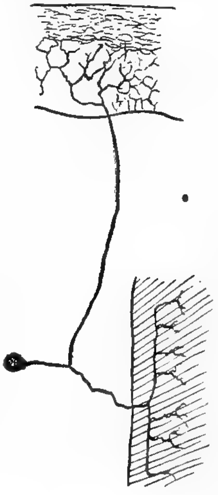

FIG. 1542.

FIGS. 1540, 1541, AND 1542. - Diagrammatic Representations of the Migration of the Peripheral Sensory Ganglion Cells from the Epidermis toward the Central Nervous System in Different Animals. (After Retzius.) Fig. 1540, Lumbricus; Fig. 1541, Limax; Fig. 1542, vertebrates.

The account here given, though based largely on Gaskell's scheme, differs from his in important respects. The main features of his analysis of the cranial and spinal nerves can be gathered from the accompanying figures and their legends (Figs. 1538 and 1539).

The accompanying table expresses the chief relations of the several components so far as known in the human body. Compare the more detailed exposition of the several nerves beyond. It should be borne in mind that the analysis here given is in several respects theoretical rather than demonstrated fact. In particular, the distribution of the cerebral motor roots in the somatic and visceral groups, as here indicated, is greatly in need of confirmation. The table is intended to present the views now most generally accepted, and must be held subject to revision and further analysis as our knowledge advances.

PHYLOGENY AND EMBRYOLOGY.—The peripheral nervous system (including probably the whole of the sympathetic system) is exclusively ectodermal in origin. In some lowly invertebrates the entire nervous system lies close under the epidermis, or even in this layer. But with the increasing demand for the correlation and integration of nervous impulses, the central system is in early phylogenetic stages specialized off to lie in the deeper layers of the body. On the other hand, the cell bodies of the peripheral nervous system may retain their peripheral position in the epidermis in animals of a much higher grade. Thus, in the earthworm the epidermis is composed of a single layer of columnar epithelium cells, among which in the cephalic region of the body are scattered spindle-shaped sensory cells, each giving rise to a nerve fibre which terminates in the central nervous system (Fig. 1540). In other invertebrates (as in the slugs) the cell body has retired a longer or shorter distance from the surface, being provided, in addition to its central process, with a peripheral process extending to the periphery (Fig. 1541). Finally, in the vertebrates the typical arrangement is given by the general cutaneous nerves, whose cell bodies have sunken as far as possible below the surface until they lie in the spinal ganglia adjacent to the spinal column (Fig. 1542). In this case, too, it will be noted that the cell body, instead of lying in the path of the fibre (bipolar), has been crowded off to one

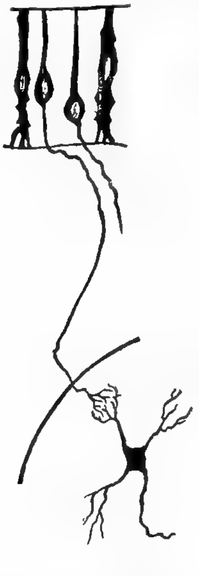

FIG. 1543.

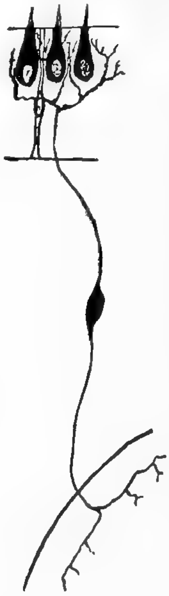

FIG. 1544.

FIG. 1543.—Diagram of the relations of the Specific Olfactory Cells of the Nose with the Central Nervous System. (After Retzius.)
FIG. 1544.—Diagram of the connections of the Auditory Ganglion Cells. (After Retzius.)

side and become unipolar. This arrangement is characteristic of the spinal ganglion cells and of most of the cranial ganglia, viz., those of the X., IX., VII., and V. nerves.

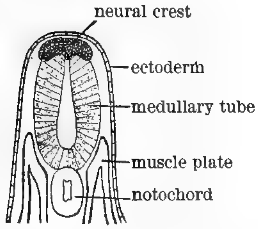

Fig. 1455.

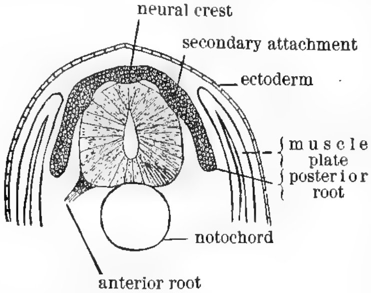

Fig. 1546.

Figs. 1545 and 1546.—Two Stages in the Development of the Neural Crest and Spinal Ganglion in the Embryo Chicken. (After Marshall.)

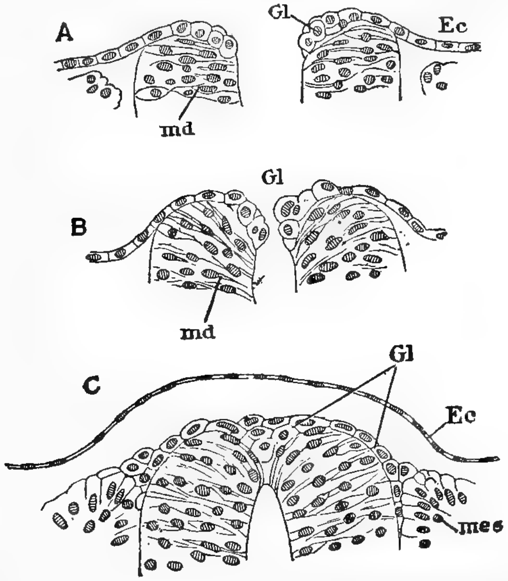

Fig. 1547.—The Formation of the Neural Crest. Sections through the cervical region of a human embryo of fourteen to sixteen days. (After v. Lenhossék.) *Ec*, Ectoderm; *mes*, mesoderm; *Gl*, neural crest; *md*, medullary plate, closing in to form the neural tube.

Not all of the nerves of the human body, however, have been specialized so far in this direction. The olfactory nerve, in fact, has retained the primitive invertebrate arrangement with but slight modification. It is the most archaic nerve of the body. The specific olfactory cells are scattered among the indifferent cells of the olfactory membrane and are provided each with a fibrous prolongation directed centrally, which pierces the basement membrane of the epithelium and forms one of the fibres of the olfactory nerve, finally to terminate in an arborization in one of the glomeruli of the olfactory bulb. The olfactory "nerve," therefore, really corresponds to the radix of a spinal sensory nerve in that it is made up of root fibres, *i.e.*, fibres passing from the ganglion to the centre. Another evidence of the primitive character of the olfactory nerve is found in the absence of medullary sheaths upon its fibres. The fibre corresponding to the peripheral process of a spinal ganglion cell never develops, since the cell body itself lies in the periphery (Fig. 1543).

The auditory nerve is intermediate between this type and that of the spinal nerves, since the cell body is bipolar and lies in the spiral ganglion midway between the periphery and the oblongata (Fig. 1544). It is therefore in this respect a more primitive type of nerve than the spinal nerve. In other respects, however, it is more highly specialized. For instance, instead of ending free in the periphery among unaltered cells, it, like the gustatory nerves, ramifies about specially modified epithelial cells which serve as receptive organs for these nerves of special sense.

There is some evidence that these nerves of special sense arise in the periphery, their ganglion cells being specialized in the ectoderm at the site of the future sensory organ. The optic nerve belongs to a distinct category, since the ectodermal rudiment of the eye and its nerve is formed on the cephalic plate before its invagination into the nerve tube, then to be secondarily evaginated from the nerve tube into its definitive position.

The other sensory nerves (and, according to the researches of His, Jr., the sympathetic system also) are derived from cells which migrate out from the ectoderm at the time of the invagination of the nerve tube at the seam, or line of contact, between the nerve tube and the unmodified ectoderm from which the latter is derived. These cells arise in some cases apparently from the ectoderm just after the neural tube has been pinched off, in other cases from the dorsal wall of the tube at a corresponding period. In either case they form a ridge or heap of cells between the dorsal edge of the tube and the overlying ectoderm, which is termed the "neural crest." Its cells now migrate down on either side of the neural tube into the definitive position of the spinal ganglion, meanwhile becoming bipolar by the growth of a fibrous process from each pole of the spindle-shaped cell body. One of these processes grows outward toward the periphery, the other inward to form the sensory root of the nerve in question. Two stages in the development of

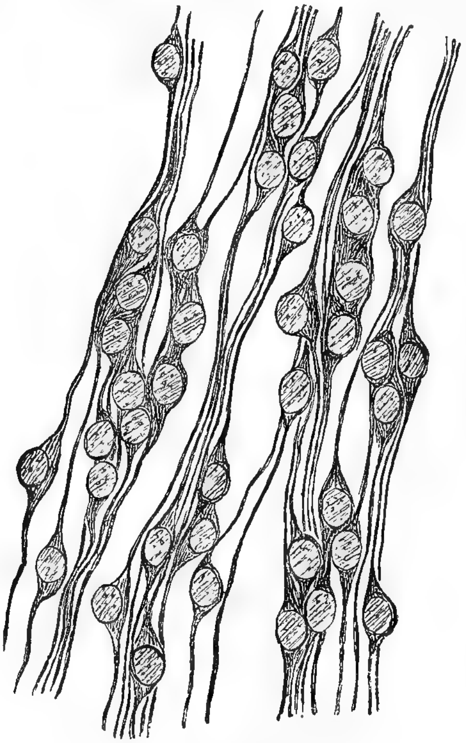

Fig. 1548.—Bipolar Spinal Ganglion Cells from a Human Embryo. (After His.)

the neural crest of the chick are illustrated in Figs. 1545 and 1546. The development of the neural crest of man is somewhat different, as may be seen in the three stages illustrated in Fig. 1547.

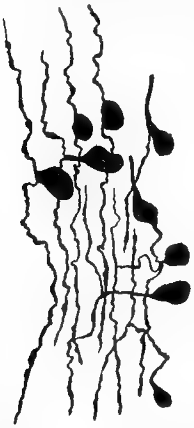

FIG. 1549.—Transformation of Bipolar into Unipolar Ganglion Cells in the Gasserian Ganglion of an Embryo Guinea-pig. (After Van Gehuchten.)

The two poles of these cells are at first opposite (Fig. 1548), but become gradually approximated until finally the cellulifugal and the cellulipetal fibres unite for a short distance and the cell becomes unipolar. Several stages in this process are shown in the accompanying figure of the Gasserian ganglion (Fig. 1549). The motor roots, as is well known, grow out from cells lying in the ventro-lateral zone of the neural tube (Figs. 1550 and 1551). The general arrangement of the cranial nerves of the adult man are indicated in Fig. 1552, while their origins from the medulla oblongata are shown more in detail in Figs. 1553 and 1554, and their foramina in Fig. 1555.

NERVES OF THE SPINAL TYPE.—The composition of the typical spinal nerve we have already given. The distribution of the chief branches of such a nerve in the thoracic region is indicated in the accompanying figure (Fig. 1556).

XII. The hypoglossus is the only cranial nerve of this type. During the evolution of the vertebrata a considerable number of the most cephalic spinal segments have been either lost or absorbed into the head and the corresponding spinal nerves have been reduced. Several such nerves were lost altogether and others lost the dorsal roots. In young specimens of the lowly elasmobranch, *Hexanchus,* there are five of these "occipital" nerves which have lost their dorsal roots (the last one with a minute dorsal root). The hypoglossus of man does not, apparently, correspond to any of these, however, but is composed (according to Fürbringer) of the ventral roots of the three following nerves (the first three occipito-spinal nerves of his nomenclature). In the human embryo a ganglion and rudimentary dorsal root may appear in connection with one or more of these roots, and rarely in the adult the last one bears a small vestige of the ganglion.

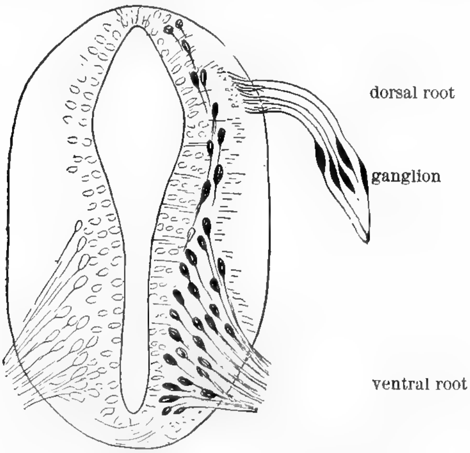

FIG. 1550. Section through the Spinal Cord of a Human Embryo of four to four and one-half weeks. (After Edinger.)

The nucleus of origin of the XII. nerve lies ventro-laterally of the tip of the fourth ventricle and is the continuation of the ventral horn of the cervical cord. The root fibres arise chiefly (and according to most authorities wholly) from the nucleus of the same side. The nucleus receives from its lateral and ventral sides a very large number of delicate terminal fibres, including doubtless reflex fibres from the sensory nerves and motor fibres from the cortex. The latter are chiefly collaterals from the pyramids, but partly, according to Hoche, terminals of fibres running down mingled with the fibres of the mesial fillet. The hypoglossus fibres emerge in from ten to fifteen rootlets, pass through the anterior condylar foramen, effect connections with the superior cervical ganglion of the sympathetic, the vagus, the first three cervical nerves, and the lingual branch of the trigeminus. They distribute mainly to the muscles of the tongue, viz., the styloglossus, hyoglossus, genio-hyoid, genio-glossus, and the intrinsic muscles of the tongue.

NERVES OF THE BRANCHIOMERIC TYPE.—*XI. The accessory nerve* consists of two parts: (1) the accessorius vagi is really a bundle of detached filaments of the vagus, containing inhibitory fibres for the heart, motor fibres for the pharynx, etc.; (2) the accessorius spinalis arises from the lateral aspect of the spinal cord as far back as the fifth or sixth cervical vertebra in numerous separate strands. These fibres are motor and arise from the lateral cornu of the cord. They turn cephalad and are collected into a single trunk and emerge through the same foramen as the vagus. They supply the sterno-mastoid and trapezius muscles.

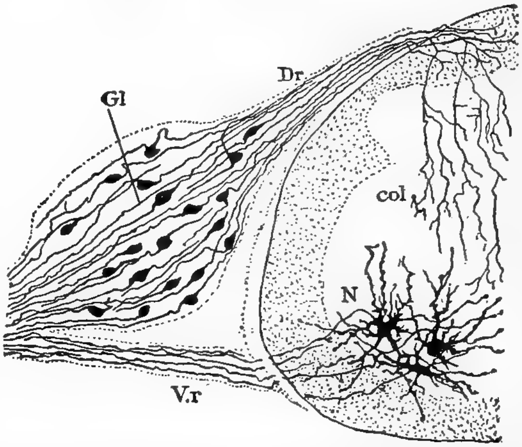

FIG. 1551.—Transverse Section of the Spinal Cord of a Chick at the ninth day of Incubation. (After Ramón y Cajal.) *V.r,* Ventral root fibres, arising from ventral horn cells, *N; Dr.,* dorsal root fibres, arising from ganglion cells, *Gl; col,* collaterals, from the latter fibres.

The morphology of the accessorius spinalis is still rather obscure. Its nucleus is a strand of cells lying in the lateral cornu and extending as far forward as the level of the lower third of the olive. In some fishes and amphibians, though a distinct accessorius is absent, yet certain fibres of the motor root of the vagus arise farther caudally than the others and supply the trapezius muscle. These are regarded as the representatives of the accessory nerve. As we pass upward in the animal series, the accessorius nucleus is extended farther caudad into the lateral horn region and this nerve is more clearly separable from the vagus. The distinction between the vagal and the spinal portions of the accessorius in any case is not of profound morphological significance, since both the accessorius and the motor vagus belong to the same component, the viscero-motor, and both are differentiated from the lateral horn zone.

IX. and X. The vagus, or pneumogastric, and the glossopharyngeus are concerned primarily with the respiratory and nutritive mechanisms. In lower vertebrates they are typical branchial nerves, or rather, the vagus is a fusion of several such, the number of branchiomeres represented corresponding to the number of gill clefts minus one, the first cleft being supplied by the IX. pair. In the lowest fishes these branchial nerves are quite separate from each other and each forks around a single gill cleft. In higher forms all but the first (IX. nerve) are fused together and the vagus stem is extended into the intestines, lungs, and other viscera connected with the metabolism of the body.

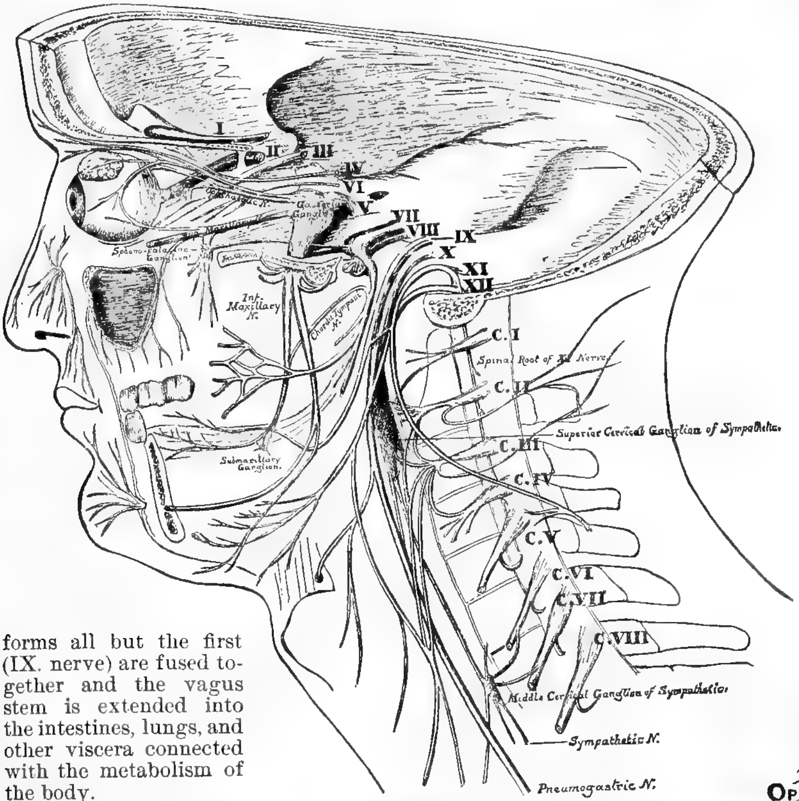

Fig. 1552.—General View of the Cranial Nerves. (Altered from Allen Thomson.)

The gill arches and their appendages are essentially visceral structures, and this has influenced the composition of these nerves. Except in some lower vertebrates, the vagus region contains no somatic muscles. When such muscles are present, they seem to be innervated from post-vagal spino-occipital nerves. Accordingly neither the vagus nor any of the other branchiomeric nerves contain somatic motor components. The general cutaneous component, too, has been greatly reduced in the post-trigeminal members of the series, the skin of this region being for the most part supplied either from behind by the spinals or from in front by the trigeminus. The vagus and glossopharyngeus, accordingly, have the following composition: (1) a small number of general cutaneous fibres, (2) visceral sensory fibres, (3) visceral motor fibres. In the fishes a large root of the lateral line system of nerves goes out through the vagus foramen and is conventionally associated with the vagus, though it has no morphological connection with it and is not represented at all in the higher animals. Compare the diagram of the acustico-lateral system, Fig. 417, Vol. I.; article *Auditory Nerve.*

1. In the fishes and amphibians the relations of the general cutaneous fibres are accurately known. Arising in a special ganglion on the root of the vagus (the jugular ganglion of Shore and Strong), they enter the spinal V. tract, to terminate about the cells associated with this tract. Peripherally they comprise dorsal branches of the nerve which supply the skin of the occipital region above and external to the gill chamber. In man most authorities describe the vagus root as simply passing through the spinal V. tract. Since, however, there is a general cutaneous twig supplying the corresponding region of the periphery (the ramus auricularis vagi, innervating the skin behind the ear), it is probably true that in man also some vagal fibres terminate in the spinal V. tract, as the gray matter associated with this tract is the only terminal nucleus in the oblongata known for general cutaneous fibres. Cajal, moreover, has demonstrated fibres entering the spinal V. tract from the IX. root.

2. The remaining sensory fibres belong to the visceral system. Their peripheral distribution in the case of the vagus is very wide, viz., to the mucous surfaces of the pharynx and to the thoracic and abdominal viscera. The presence of these latter fibres is the probable explanation of the small number of the visceral sensory fibres in the spinal nerves. They spring mainly from the ganglion of the trunk (g. nodosum). Proximally of the ganglion these sensory fibres cannot easily be distinguished from the smaller motor fibres. Together they enter the oblongata in a series of twelve or more filaments in the groove between the olive and the restiform body. In lower vertebrate types the visceral sensory (communis) component of both the IX. and X. nerves contributes fibres for the general sensory innervation of the mucosa of the pharynx and adjacent regions, and in addition a still larger number

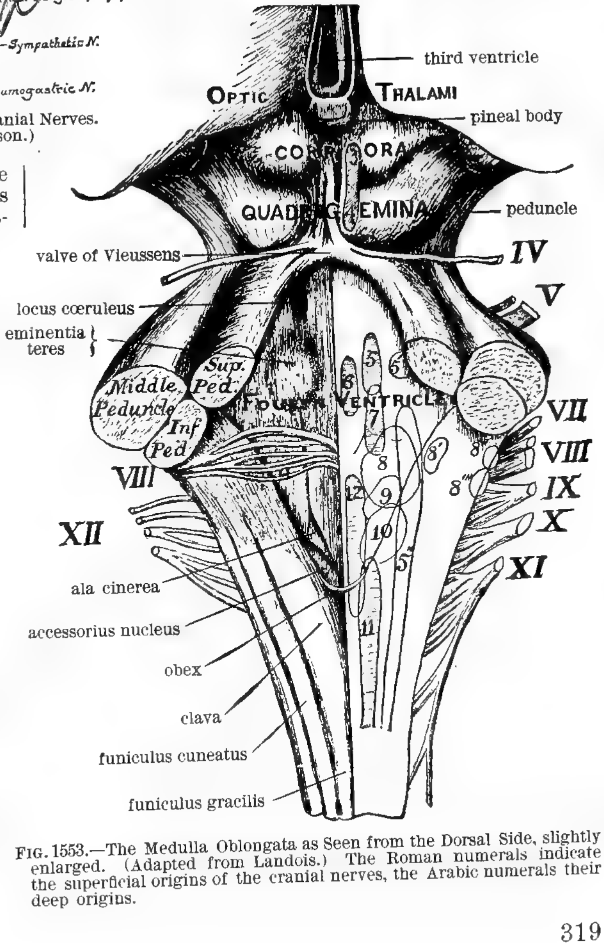

Fig. 1553.—The Medulla Oblongata as Seen from the Dorsal Side, slightly enlarged. (Adapted from Landois.) The Roman numerals indicate the superficial origins of the cranial nerves, the Arabic numerals their deep origins.

of fibres to the large taste buds plentifully scattered over the gills. In all cases the IX. sends a branch forward on to the dorsal surface of the hyoid (rudimentary tongue).

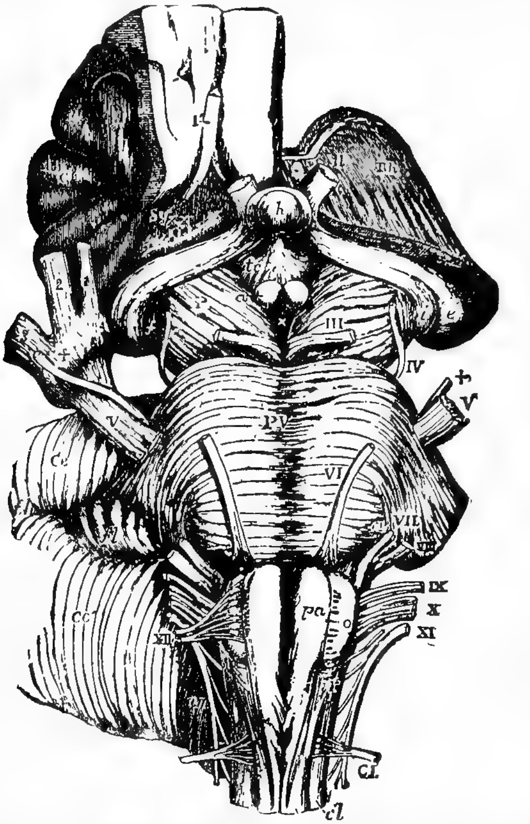

FIG. 1554.—The Medulla Oblongata and Parts Adjacent as seen from the Ventral Side. Natural size. (After Allen Thomson, from Quain's "Anatomy.") The Roman numerals refer to the cranial nerves; *ca*, ventral column of cord; *cl*, lateral column; ventral median fissure of cord; *o*, olive; *P*, cerebral peduncle; *pa*, pyramid; *PV*, pons Varolii.

With the disappearance of the gills, the taste buds of the corresponding regions vanish, and, accordingly, the lingual branch of the IX. is the only nerve of this complex which serves the function of taste in man, though, as we shall see beyond, the VII. nerve also participates. The IX. nerve of man enters the brain by some five or six rootlets in a line directly continuous with the vagus roots. The general cutaneous fibres enter the spinal V. tract, the communis fibres the fasciculus solitarius, and the motor fibres the cephalic end of the nucleus ambiguus.

3. In the fishes there are clearly two kinds of motor fibres in the vagus and glossopharyngeus, viz., large fibres arising from the nucleus ambiguus and destined for the striated musculature of the gills, and smaller fibres destined for the unstriated œsophageal and other visceral muscles of uncertain origin. Most of the motor fibres in man are of the small variety. It is universally agreed that they arise, in part at least, from the nucleus ambiguus (accessory vago-glossopharyngeal nucleus), which is a highly differentiated continuation of the lateral horn.

Besides the nucleus last mentioned and the connection of the IX. and X. roots with the spinal V. tract already indicated, there are two other centres, the fasciculus solitarius (fasc. communis of the Ichthyopsida) and the cells associated with it to form the "spinal nucleus," and the so-called "chief nucleus," the latter lying dorsomesially of the fasciculus between it and the IV. ventricle. It has been commonly held that the sensory vagus terminates mainly in the chief vago-glossopharyngeus nucleus, but partly in the fasciculus solitarius, while the IX. terminates chiefly in the fasciculus, but partly in the chief nucleus. Cajal from a study of Golgi preparations of the IX. and X. nerves of the new-born mouse concludes: "There are, therefore, in this animal not two sensory terminal clusters, nor two separate portions for the two nerves. A single root common to both nerves passes over into the fasciculus solitarius without loss of any fibres, in such a way that between the upper or chief nucleus and the lower or descending nucleus there is no distinction aside from that of position." Some years ago Forel, and since him several other careful workers, by a variety of the degeneration methods, have come to the conclusion that the so-called "chief sensory nucleus" is either wholly or largely motor in function, and that the fasciculus solitarius and the gray matter immediately adjacent to it represent the only sensory terminus for these communis fibres of the IX. and X. roots.

The presence of a descending or spinal root and nucleus in these nerves may be correlated with the corresponding feature of the dorsal roots of the spinal nerves. As each dorsal root fibre typically divides immediately upon entrance into the cord into a descending and an ascending limb, so here the entering sensory fibres have been seen to divide, one limb descending to form the fasciculus solitarius and enter the spinal nucleus. The sensory roots of the VIII., VII., and V. nerves exhibit the same peculiarity.

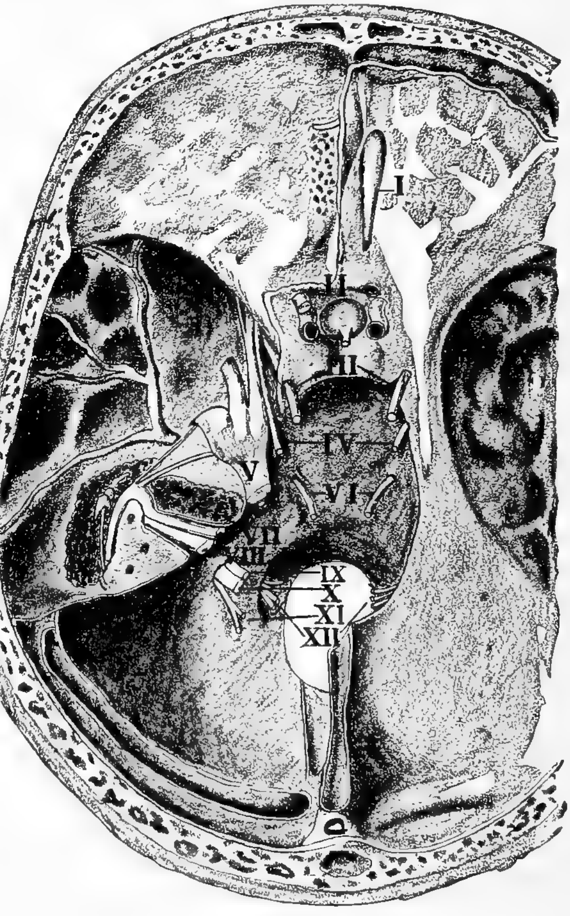

FIG. 1555.—The Base of the Skull, showing the Exits of the Cranial Nerves.

The peripheral relations of the vagus and glossopharyngeus are illustrated in the accompanying figure (Fig. 1557). The lingual branch of the IX. supplies the mucous membrane and circumvallate papillæ of the back part of the tongue, the pharyngeal branches supply the stylo-pharyngeus muscle, and perhaps some of the constrictors of the pharynx, together with the mucous membrane adjacent. By its tympanic branch (nerve of Jacobson) it supplies the mucous lining of the middle ear. It communicates with the V., VII., and X. and sympathetic nerves.

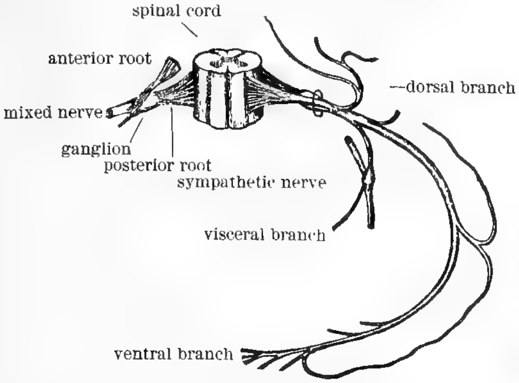

FIG. 1556.—Diagram of a Spinal Nerve of the Thoracic Region.

The vagus communicates with the VII., IX., XI., XII., I. and II. spinals, and the sympathetic. Its distribution is extensive, comprising branches to the dura mater, external ear, pharynx, larynx, heart, lungs, stomach, and other viscera. Throughout its entire extent the vagus is in frequent communication with the sympathetic, and it seems to share many of its functions with the latter. It controls, more or less directly, the more important automatic and vegetative functions of the body, such as circulation and digestion, and is thus of the most profound physiological significance. Its vaso-motor function is of the most far-reaching significance. It carries three types of cardiac fibres, viz., accelerator, inhibitory, and depressor, the latter acting centripetally to produce reflexly a slowing of the heart. Trophic fibres have frequently been described in the vagus, though the weight of evidence now points to the belief that such fibres have no separate existence.

VII. Facialis.—In the lower fishes the facialis is a typical branchiomeric nerve. The hyoid arch is a modified gill arch, as evidenced by perfect gills on its posterior face, and it is separated from the mandibular arch by the spiracular cleft, around which the facialis forks in just the same way as the other branchial nerves fork around their respective gill clefts (*cf.* Fig. 1537). The facialis, too, has the typical roots, viz., visceral motor and visceral sensory (communis), the latter very large in lower vertebrates but small in man and known as the portio intermedia of Wrisberg. It always has a ganglion, the geniculate ganglion. Moreover, the facial branches have the typical composition, the post-trematic nerve being motor and sensory, the pre-trematic and the palatine exclusively sensory. The post-trematic ramus corresponds to the main facial trunk in man, the pre-trematic, or a portion of it, probably to the chorda tympani, and the palatine is unquestionably the great superficial petrosal of human anatomy, the spiracular cleft being represented by the Eustachian tube. In none of the lower vertebrates do general cutaneous fibres emerge from the brain with the facial roots, though they may enter the facial trunk peripherally, running back into it from the Gasserian ganglion. In the Ichthyopsida a very large root of the acustico-lateral system joins the facialis, passing out with the post-trematic ramus to supply the lateral line organs of the mandible (see *Auditory Nerve*, Fig. 417, Vol. I.).

Between these lower vertebrates and man the facial nerve undergoes a striking metamorphosis. There it is a large nerve, chiefly sensory, whose sensory fibres have a very wide distribution to specialized sense organs of the inside of the buccal cavity and also to varying extents all over the outer skin of the head and trunk, while the motor component is small and confined to the innervation of the muscles of the hyoid arch. In man, on the other hand, the sensory portion has dwindled to so small proportions as to have been quite ignored by many anatomists, while the peripheral distribution area of the motor portion has been enlarged to include almost the whole of the superficial facial musculature. The reduction of the sensory component is explained by the loss of the corresponding sense organs in air-breathing vertebrates, while the muscles of expression of the face are said to be derived phylogenetically from the hyoidean musculature.

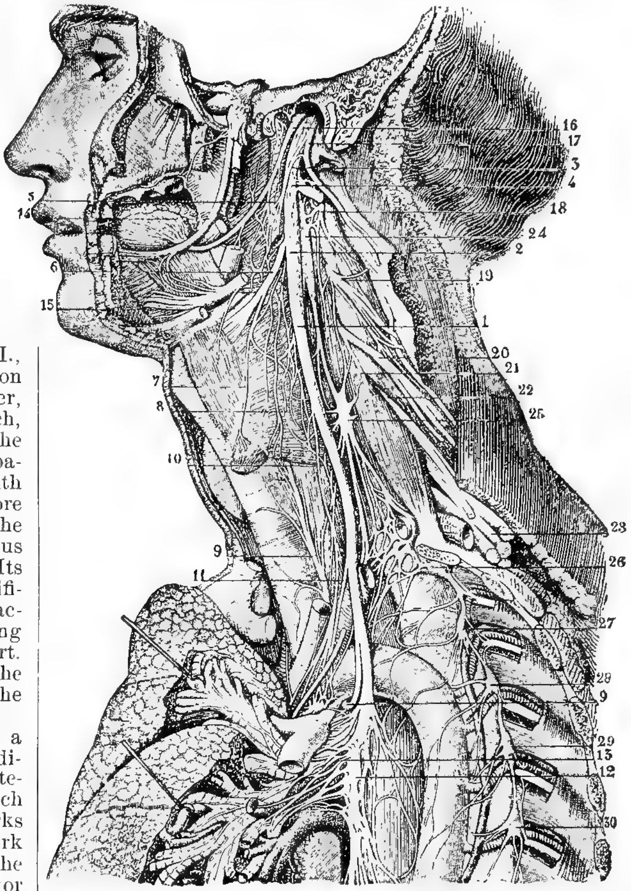

FIG. 1557.—The Distribution and Connections of the IX. and X. Nerves. (After Hirschfeld and Leveillé, from Quain's "Anatomy.") One-third.

1, Vagus nerve; 2, ganglion of its trunk; 3, accessory part of the spinal accessory; 4, union of the X. and XII. nerves; 5, pharyngeal branch of the vagus; 6, superior laryngeal nerve; 7, exterior laryngeal; 8, communication of the latter with the superior cardiac branch of the sympathetic; 9, inferior or recurrent laryngeal; 10, superior, and 11, inferior cervical cardiac branches of the vagus; 12, 13, posterior pulmonary plexus; 14, lingual branch of the mandibular branch of the V.; 15, distal part of the hypoglossal nerve; 16, glossopharyngeus; 17, spinal accessory nerve, uniting by its inner branch with the vagus, and by its outer passing into the sterno-mastoid muscle; 18, II. cervical nerve; 19, III.; 20, IV.; 21, origin of the phrenic nerve; 22, 23, V., VI., VII., and VIII. cervical nerves, forming with the first thoracic the brachial plexus; 24, superior cervical ganglion of the sympathetic; 25, middle cervical ganglion; 26, inferior cervical ganglion, united with the first thoracic ganglion; 27, 28, 29, 30, second, third, fourth, and fifth thoracic ganglia.

In man the two roots emerge from the brain in close contact at the lower border of the pons and in intimate relations with the auditory nerve. The motor root arises in a nucleus lying ventrally and slightly caudally of that of the VI. nerve. Its fibres are uncrossed, according to Van Gehuchten, though several earlier authors describe a crossed bundle also. They curve around the VI. nucleus, forming the inner genu of the root, and upon emergence from the oblongata are joined by those of the portio intermedia. The internal genu is a very characteristic feature of this root in all vertebrates. Its significance is perhaps to be explained by a relation between the facialis root and the fasciculus longitudinalis medialis. Connections of different kinds have been described between this fasciculus and the motor cranial roots. The writer has observed these connections in the fishes and, in two of the cases (viz., the IX. and VII.), the motor roots depart far from the shortest courses to their superficial origins to run for some distance along the outer side of the fasciculus. The bundle from the IX. nucleus divides before leaving the fasciculus into two nearly equal portions, of which one forms the root bundle and the other remains with the fasciculus. The ascending limb of the facial root in the same way runs along the outer side of the fasciculus for some distance immediately ventrally of the glossopharyngeal bundle, with which it finally fuses. The root portion, or descending limb of the facial root, soon separates, presumably leaving some fibres in contact with the IX. bundle, which soon fuses, a little farther cephalad, with the rest of the fasciculus longitudinalis medialis. In human anatomy, too, the facial genu passes along the outer side of this fasciculus, and there may be some relation between them, by means of collaterals or otherwise.

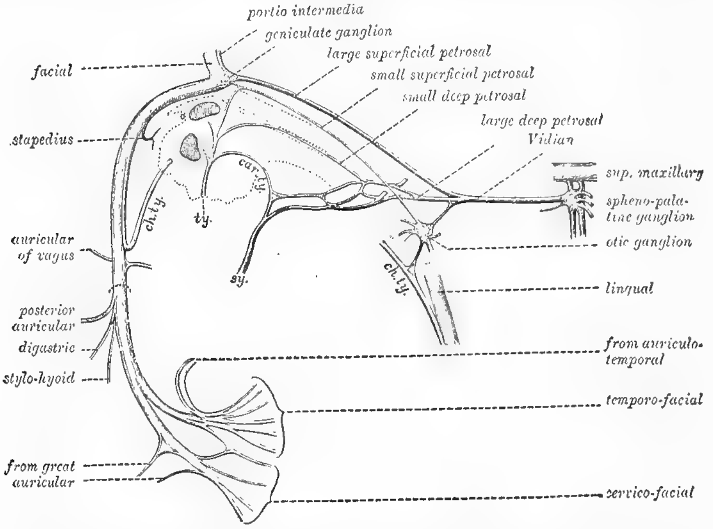

FIG. 1558. -Plan of the Facial Nerve. (After Thane, from Quain's "Anatomy.") *ch.ty.*, Chorda tympani, its middle part removed; *ty.*, tympanic branch of the glossopharyngeus; *sy.*, sympathetic on the internal carotid artery; *car.ty.*, carotico-tympanic nerve, passing between the tympanic nerve and the sympathetic in the carotid canal.

The sensory facialis fibres arise in the geniculate ganglion and terminate in the fasciculus solitarius (= fasc. communis) and the associated gray matter, thus reaching the same terminal nucleus as the other members of the communis system. The two roots run outward, accompanying the auditory nerve to the internal auditory meatus. Separating from the latter nerve they enter the aqueduct of Fallopius, within which a sharp turn is made, the external genu of the nerve. At this point is the geniculate ganglion, which is the root ganglion of the sensory portion. Within the aqueduct the following branches are given off from the trunk: (1) twigs communicating with the auditory nerve, (2) with the small superficial petrosal, and (3) with the auricular branch of the vagus; (4) a motor twig for the stapedius muscle; (5) the external superficial petrosal nerve; (6) the great superficial petrosal nerve, wholly sensory and corresponding to the palatine of lower vertebrates, which is joined by the large deep petrosal to form the vidian nerve, terminating in the spheno-palatine ganglion; (7) the chorda tympani, a sensory nerve which leaves the trunk at the outer end of the aqueduct and curves back through the temporal bone and the tympanic cavity, to run forward, receiving a communicating twig from the otic ganglion, to join the lingual branch of the trigeminus. The fibres of the chorda are now generally regarded as largely gustatory in function, while those of the lingual branch of the trigeminus are concerned with general sensibility only. This accords with our most precise anatomical and phylogenetic knowledge and with a large body of clinical and pathological data, though there is some clinical evidence pointing to the existence of gustatory fibres in the trigeminus.

The facial trunk, upon emergence from the Fallopian aqueduct, is generally described as purely motor, but Van Gehuchten has very recently demonstrated a few sensory fibres in it from the geniculate ganglion. The motor fibres are distributed to the stylo-hyoid and posterior belly of the digastric muscles, to the muscles of the ear, scalp, and eyelids, and to the superficial facial musculature in general. The facial fibres for the frontalis, orbicularis palpebrarum, and corrugator supercilii muscles are said by some authorities to arise in the oculomotor nucleus and to descend to the facial root through the fasciculus longitudinalis medialis, and by others to arise in the VI. nucleus. Van Gehuchten has shown by Nissl's degeneration method that both of these suppositions are incorrect. He has analyzed the VII. nucleus of the rabbit as shown in Fig. 1559. Some authors have also described fibres passing from the facial root into the terminal nucleus of the spinal V. tract, presumably of general cutaneous nature; but this remains unconfirmed.

The motor VII. nucleus receives terminal fibres (1) from the pyramidal tracts of the same and the opposite side; (2) from another tract of motor fibres which descends from the cortex in the region of the medial fillet, and hence quite independently of the pyramids (Hoche —this tract also effects connections with the XII. nucleus, as already mentioned); (3) from the sensory V. root; (4) from the opposite nervus cochleæ via the corpus trapezoides; (5) from the fundamental lateral column.

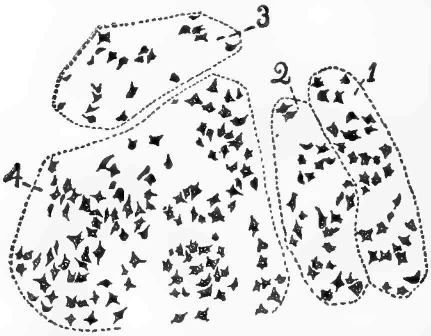

FIG. 1559.—Muscular Localization in the Facial Nucleus of the Rabbit. (After Van Gehuchten.)

1, Cells of the internal group related to the stapedius muscle; 2, cells of the internal group related to the muscles of the outer ear; 3, nucleus of origin of the fibres of the superior facial; 4, nucleus of origin of the fibres of the inferior facial, the inner portion related to the fibres of the inferior bucco-labial branch, the outer portion to those of the superior bucco-labial.

The secondary connections of the sensory root are not so well known, but are doubtless made in the general complex of the lateral fillet.

V. The Trigeminus.—The composition and distribution of the trigeminus are remarkably constant throughout the vertebrate phylum. It innervates the muscles of mastication, and mediates general sensibility of the face and teeth. In lower vertebrates it is usually larger in proportion than in man. Its morphological position is very obscure. Superficially it resembles rather closely the typical branchiomeric nerves, since it forks around the mouth as they do around the gill clefts, the motor component enters the post-trematic (mandibular) ramus only, etc. The motor root in origin and peripheral relations is essentially like that of the other nerves of this series; but the sensory root is composed wholly of general cutaneous fibres, with apparently no communis element whatever. This exaggeration of the general cutaneous component is probably a secondary arrangement, due to the reduction of general cutaneous fibres in the following nerves of the gill region of lower vertebrates and to a similar reduction in the pre-trigeminal region on account of the differentiation of the organs of higher sense. There is evidence that the general cutaneous component of at least one pre-trigeminal segmental nerve has fused with the trigeminus; for in lower sharks there is a distinct "profundus" nerve in front of the trigeminus and similar to it, a nerve which may be represented by the nasal branch of human anatomy.

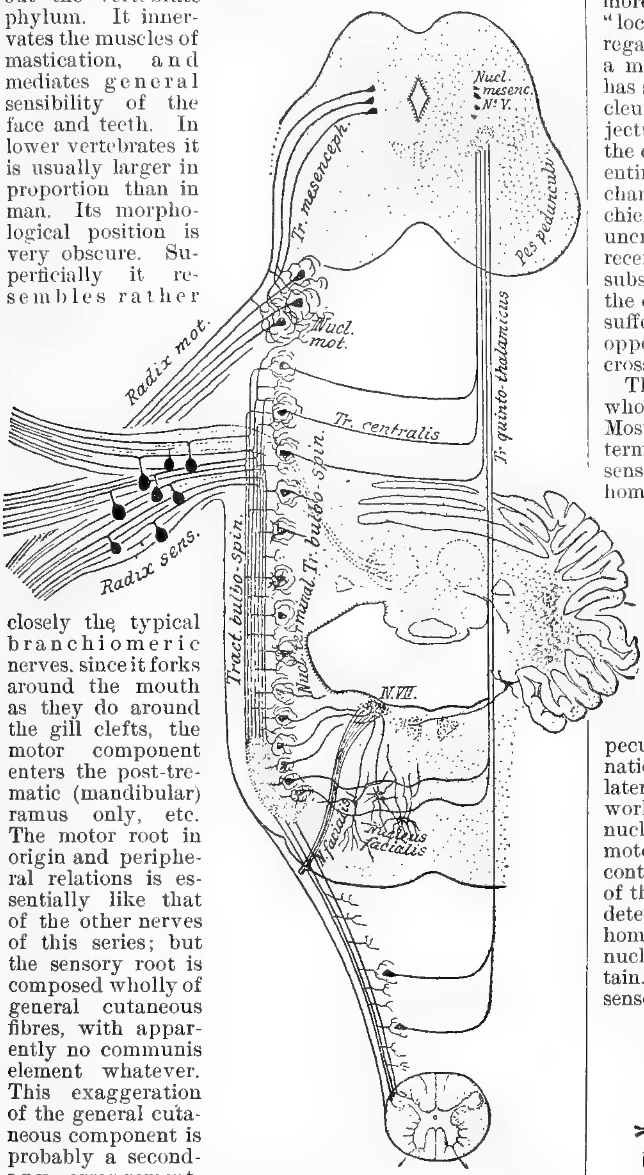

FIG. 1560.—Plan of the Trigeminus and some of its Connections. (After Edinger.)

The trigeminus arises by two roots. The portio minor, or motor root, whose fibres are commonly regarded as belonging to the viscero-motor system, springs from two groups of cells. (1) The "chief motor nucleus" lies dorsally of the exit of the nerve from the medulla oblongata, and is the morphological continuation of the facial nucleus. (2) A smaller number of fibres arises in an elongated cluster of large cells arranged sparsely along the side of the aqueduct, and constitutes the mesencephalic, or "descending" root. The cells of its lower portion are more crowded and are rich in pigment, constituting the "locus cœruleus." The mesencephalic nucleus has been regarded as trophic and as vaso-motor in function. As a matter of fact, its function is quite unknown. Cajal has shown that collaterals from the fibres from this nucleus envelop the cells of the chief nucleus, and he conjectures that this is a sort of relay mechanism by which the cells of the mesencephalic and chief nucleus (*i.e.*, the entire masticatory apparatus) can be simultaneously discharged by the same stimulus. The fibres from the chief motor nucleus are commonly described as mainly uncrossed, but partly crossed; but Van Gehuchten has recently found upon section of the trigeminus roots and subsequent examination by Nissl's method that all of the cells of both the chief and the mesencephalic nucleus suffer chromatolysis on the same side, but none on the opposite side. This leads him to the conclusion that crossed fibres do not arise from either nucleus.

The portio major is a complex structure, chiefly, if not wholly, sensory. Two roots can be distinguished: (1) Most of the fibres go to the spinal trigeminal tract and terminate in cells lying in its path (including the "chief sensory nucleus" of the trigeminus), and are therefore homologous with those of the dorsal roots of the spinal nerves, and like them belong to the general cutaneous system. This *spinal root*, often incorrectly called the "ascending root," runs down near the lateral aspect of the oblongata and can be traced, diminishing caudad, as far as the first or second cervical nerve. It is accompanied for its entire length along the inner aspect by a sparse collection of cells, the spinal nucleus of the trigeminus, which are enveloped by a dense mesh of fine terminal fibrils derived from the root fibres, the whole when stained by ordinary methods presenting a peculiar appearance which has given rise to its designation, "substantia gelatinosa." Vast numbers of collaterals from the root fibres participate in this meshwork. Others of these collaterals terminate in the motor nuclei of the V. and VII., and probably in the other motor cranial nuclei also. The homology and direct continuity of the spinal nucleus with the dorsal cornu of the spinal cord give us an important landmark for the determination of homologies in the oblongata. The homologies in the spinal cord of the other cranial nerve nuclei, both sensory and motor, are much more uncertain. (2) The second root of the portio major is the sensory cerebellar root of Edinger (indicated by dotted lines in Fig. 1560), which enters the cerebellum by way of the prepeduncle. The existence of this root is denied by some authors.

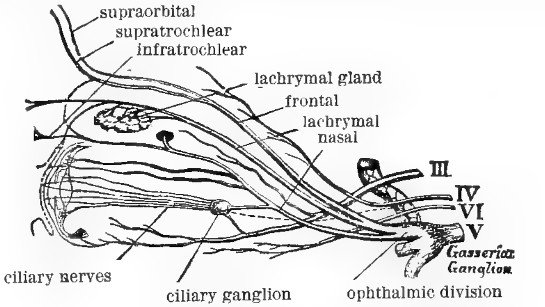

FIG. 1561.—The Nerves of the Left Orbit. (After Young, reduced.)

The central connections of the motor V. nuclei are doubtless made from the pyramidal tracts, though they are not very precisely known. The chief motor nucleus also receives collaterals from the sensory nuclei of the oblongata. The sensory V. nucleus effects secondary connections with the motor cranial nuclei and with the higher centres via the lateral fillet of the same and the opposite side.

The three main branches of the trigeminus (which give the nerve its name) arise directly from the Gasserian ganglion. For the details of their distribution, see the figures. (1) The ophthalmic nerve is wholly sensory (Fig. 1561). It communicates with the sympathetic, III., IV., VI., and VII., nerves. Its first branch is a recurrent meningeal twig for the tentorium, after which it divides into nasal, frontal, and lachrymal branches. The nasal nerve furnishes the long root of the ciliary ganglion (a ganglion of the sympathetic system), the long ciliary nerves, twigs for the conjunctiva, lining of the nasal fossa, and skin of the tip of the nose. The frontal nerve supplies the conjunctiva and skin of the upper eyelid and the forehead. The lachrymal branch innervates the lachrymal gland, conjunctiva, and adjacent skin. (2) The maxillary nerve (Fig. 1562) is also wholly sensory, supplying the skin of the side of the face (cheek, temple, lower eyelid, nose, and upper lip), the mucous lining of the nose and upper part of the pharynx and the teeth of the upper jaw, and communicating with the sympathetic spheno-palatine ganglion. (3) The mandibular nerve (inferior maxillary) receives the remainder of the general cutaneous fibres and all of the motor fibres of the trigeminal roots. The motor fibres supply the following muscles: temporal, masseter, external and internal pterygoid, tensor palati, tensor tympani, mylohyoid, and the anterior belly of the digastric. The sensory fibres supply the skin of the lower jaw, side of the head, external ear, external auditory meatus, teeth of the lower jaw, tongue (general sensation only), mucous lining of the mouth and other parts adjacent. It communicates with the facialis and with the otic and submaxillary ganglia of the sympathetic system. The lingual branch is joined by the chorda tympani from the geniculate ganglion of the facial nerve, and there has been much discussion regarding the exact courses of the fibres of these two nerves. The weight of evidence is clearly in favor of relegating the gustatory fibres all to the chorda and excluding this component from the trigeminus entirely.

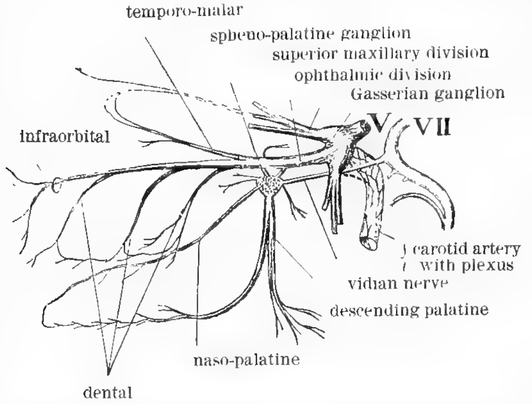

FIG. 1562.—Plan of the Maxillary Division of the Trigeminus as seen from the Left Side. (Altered from Young.)

Summary of the Nerves of the Branchiomeric Type.—These nerves typically comprise the following branches, viz.: (1) dorsal general cutaneous branches for the outer skin; (2) sensory pharyngeal branches for the mucosa of the roof of the pharynx, of communis nature; (3) a pretrematic branch for the gill on the anterior side of the corresponding gill cleft and its contained sensory organs, wholly sensory (communis); (4) a post-trematic branch for the gill on the posterior side of the cleft and its contained sense organs, together with the branchial musculature of that segment (communis and viscero-motor).

With the loss of the gills in higher vertebrates, this relation is obscured, the vagus preserving the dorsal cutaneous branch and the IX. and X. retaining the communis and motor roots with great modifications in their peripheral relations. The VII. pair is more nearly typical, having lost the cutaneous component, reduced the communis, and enlarged the motor. The V. pair is the most highly modified of all, having lost the communis element and enormously exaggerated the cutaneous, the motor remaining typical. In all vertebrates except the very lowest the centres within the oblongata for these systems are not repeated in serial metameric order for the successive pairs of nerves, as tends to be the case in the spinal nerves, but each system has been concentrated centrally and unified by the coalescence of all of the terminal nuclei into a single centre, independently of the roots by which these fibres may reach the periphery. This is more obvious in the case of the sensory fibres than the motor, whose nuclei of origin are for the most part distinct. Thus, the communis fibres (visceral and gustatory) enter the brain by the X., IX., and VII., roots, but all terminate in a single nucleus associated with the fasciculus solitarius. This admits of the unification of their cortical and other secondary connections. This applies also in the case of the fishes, where the taste buds are much more widely distributed in the pharyngeal cavity and even over extensive areas of the outer skin. In the same way the general cutaneous fibres, whether they enter by the V., the IX., or the X. root, all terminate in the gray matter associated with the spinal V. tract, the substantia gelatinosa, and the chief sensory nucleus of the trigeminus. The primary connections of the branchiomeric nerves of man are shown in the accompanying diagram (Fig. 1564).

THE EYE-MUSCLE NERVES.—These nerves (including the III., IV., and VI. pairs in all vertebrates) are commonly regarded as arising from a cephalic continuation of the ventral horns. The evidence for this is chiefly embryological. The muscles innervated are derived from the somites of the head, and are the only cranial muscles of the adult known to be so derived, save those which have migrated forward from the hypoglossus region. Their nuclei of origin lie in the floor of the ventricle and far removed from other somatic motor nuclei.

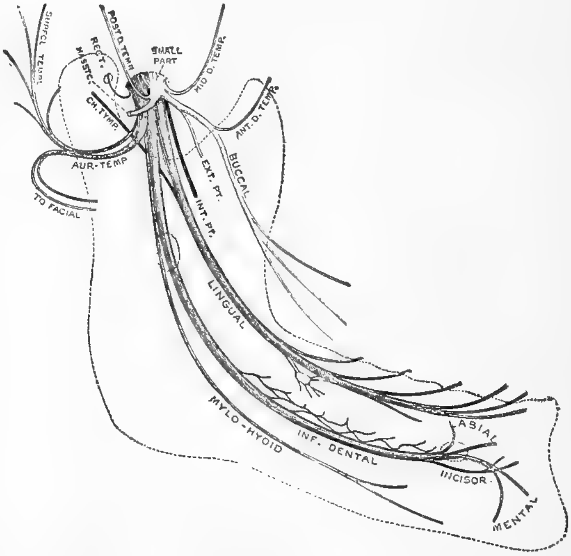

FIG. 1563.—Plan of the Mandibular Nerve. (After Thane, from Quain's "Anatomy.")

VI. Abducens.—This is the simplest of the eye-muscle nerves. Its nucleus lies in the floor of the fourth ventricle, enclosed by the genu of the facialis, and its fibres pass out on the ventral surface of the brain just behind the pons. It pursues a direct course to the m. rectus externus, receiving minute filaments from the carotid plexus of the sympathetic and from the ophthalmic branch of the trigeminus. The connections of its nucleus are: (1) by collaterals from the sensory cranial nerve roots (especially the trigeminus), (2) from the cerebral motor paths, (3) from the superior olive, (4) from the fasciculus longitudinalis, connecting with the pregeminum, or superior member of the corpora quadrigemina.

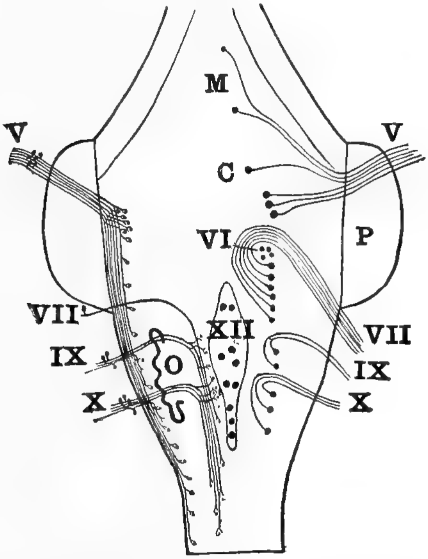

FIG. 1564.—A Diagram of the Primary Connections of the Nerves of the Branchiomeric Type of Man (including the Nuclei of Origin of the VI. and XII. Nerves). (Combined from Obersteiner and other sources.) The motor roots are entered on the right side of the figure, the sensory roots on the left. The diagram shows the serial arrangement of the motor nuclei and the unification of the sensory fibres in connection with the fasciculus solitarius (VII., IX., and X. nerves) and the spinal V. tract (V., IX., and X. nerves). Compare FIG. 1553 and also the arrangement in the fish, FIG. 1535. *C*, the locus cœruleus; *M*, the mesencephalic nucleus of the trigeminus; *O*, the olive; *P*, the pons Varolii.

IV. Trochlearis.—The nucleus of the IV. nerve lies in the floor of the aqueduct just caudad of that of the III. nerve. The fibres curve outward, dorsally and backward to emerge from the brain above the aqueduct and behind the postgeminum, there to decussate completely in the valve of Vieussens, thence to run forward to supply the superior oblique muscle. It is joined by filaments from the sympathetic and from the ophthalmic branch of the trigeminus.

III. Oculomotorius.—The fibres of the third nerve arise chiefly from a collection of nuclei in the floor of the aqueduct under the pregeminum. They pass directly ventrally in about twelve bundles which emerge on the inner face of the crus cerebri near the median line and distribute to four of the six extrinsic muscles of the eyeball, to the levator palpebræ and through the ciliary ganglion to the intrinsic muscles of accommodation. This nerve receives a twig from the cavernous plexus of the sympathetic and another from the ophthalmic branch of the trigeminus. The details of its peripheral courses may be gathered from the accompanying figures and their descriptions (Figs. 1565 and 1561).

The Nuclei and Central Connections of the Eye-Muscle Nerves.—The nuclei of the III. and IV. nerves comprise a very complex aggregate of cells lying in the floor of the aqueduct from the region of the upper (cephalic) end of the postgeminum to the III. ventricle. The lowest cluster gives rise to the IV. nerve. Regarding the details of the disposition of the fibres from the other clusters, there is still great diversity of opinion. Aside from the principal oculomotor nucleus (which Perlia subdivides into four nuclei), there is an unpaired median nucleus of large cells which seems to be related to the intrinsic muscles of the eyeball. Laterally of this there is on each side a nucleus of small cells, the nucleus of Edinger-Westphal; farther cephalad and near the median line, the "antero-median" nucleus; and laterally and dorsally of this the nucleus of Darkschewitsch. The three last mentioned probably (and quite certainly in the case of the nucleus of Darkschewitsch) have nothing to do with the oculomotor nerves.

Some of the oculomotor root fibres have a crossed origin, though most of them are direct. Van Gehuchten has recently studied this question by the degeneration method of Nissl, confirming and adding to the data of former investigators. The crossed fibres of the third nerve in the rabbit arise from the dorsal part of the nucleus. The nerves for the m. rectus superior (and perhaps for the m. levator palpebræ) are mainly of crossed origin, while a very few fibres for the mm. obliquus inferior and rectus internus are also crossed. Though the fibres of the IV. nerve all appear to cross in the valvula, yet a very few cells of the nucleus of the same side are affected by the process of chromatolysis (in the rabbit). No fibres of the VI. nerve have a crossed origin.

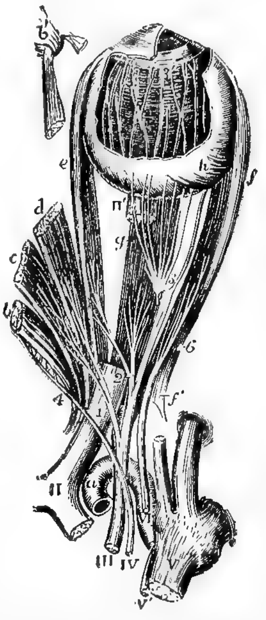

FIG. 1565.—View from Above of the Motor Nerves of the Eyeball and Its Muscles. (From Quain's "Anatomy.")

a, Upper part of the internal carotid artery emerging from the cavernous sinus; *b*, superior oblique muscle; *b'*, its anterior part passing through the pulley; *c*, levator palpebræ superioris; *d*, superior rectus; *e*, internal rectus; *f*, external rectus; *f'*, its upper tendon turned down; *g*, inferior rectus; *h*, insertion of inferior oblique muscle; II, optic commissure; II', part of the optic nerve entering the eyeball; III, common oculomotor; IV, trochlearis; V, large root of the trigeminus; V', small, or motor root; VI, abducens; 1, upper division of III. nerve, giving twigs to the levator palpebræ and superior rectus; 2, branches of the lower division supplying the internal and inferior recti muscles; 3, the long branch of the same nerve, proceeding forward to the inferior oblique muscle, and close to the number 3 the short root of the ciliary ganglion; this ganglion is also shown receiving from behind its long root, which has been cut short, and giving forward some of its ciliary nerves which pierce the sclerotic coat; 3', marks the termination of some of these nerves in the ciliary muscle and iris, after having passed between the sclerotic and choroid coats; 4, the trochlear nerve entering the upper surface of the superior oblique muscle; 6, the abducens nerve passing into the external rectus.

The eye muscles are provided with the usual muscular sensory organs (muscle spindles and tendon organs), and these have been shown by Sherrington to be supplied by sensory fibres which come out with the so-called motor roots of their nerves, and not to be derived from the anastomosing twigs from the trigeminus. Their internal connections are unknown.

The great clinical importance of oculomotor symptoms has been a stimulus for much research upon the secondary connections of the oculomotor nuclei. Nevertheless, our knowledge of these connections is still very incomplete. Certain cells in the pregeminum which are related to the termini of the optic nerve in this region appear to send their neurites into the fasciculus longitudinalis medialis, and thus put the terminal nuclei of the optic nerve into relation with the nuclei of the eye-muscle nerves, for it is well known that all of these nuclei are related to this fasciculus. Kölliker, Darkschewitsch, and others have described other connections between the opticus and the oculomotorius. The fasciculus longitudinalis medialis, according to Kölliker, also serves as a path of communication between the sensory nerves of the cord and oblongata and the oculomotor nuclei, and the VI. nucleus receives collaterals directly from the sensory root of the V.

All of the oculomotor nuclei receive collaterals from the pyramidal tract which arborize about their cells, and doubtless constitute the paths of conduction of oculomotor impulses from the cortex. The lower cervical and upper thoracic region of the spinal cord contains a "cilio-spinal centre" controlling certain oculomotor movements, particularly dilatation of the pupil, elevation of the upper lid, and protrusion of the eyeball. These connections are effected through the great sympathetic via the rami communicantes of the lower roots of the brachial plexus. All of the oculomotor nuclei of each side are probably intimately related through the fasciculus longitudinalis medialis. Duval and Laborde have described also a tract from the VI. nucleus to the III. and IV. nuclei of the opposite side, particularly to the centre for adduction in the III. nucleus, thus providing a direct neural connection for conjugate movements of the eyes in the horizontal plane. The supposed course of the tract is diagrammed in Fig. 1566. Recent degeneration experiments on the lower animals have not revealed this tract; some such connection (either by way of this tract or of the fasciculus longitudinalis medialis to the opposite root fibres of the III. nerve) is, nevertheless, called for by abundant clinical data.

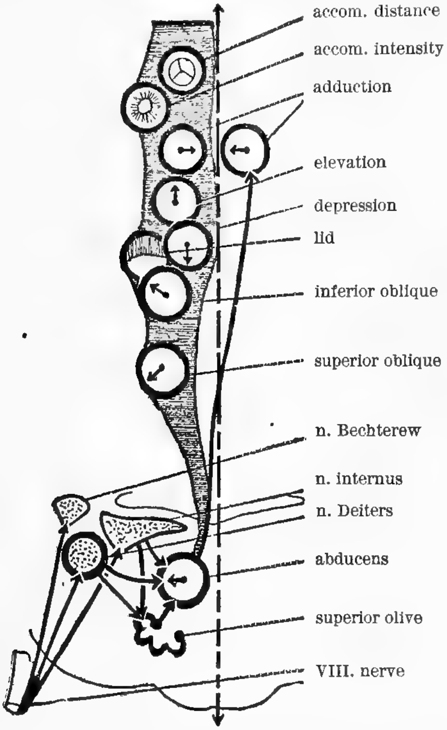

FIG. 1566.—Diagram of the Ampullo-Oculomotor Connections. (After Bonnier.)

Various connections between the VI. nucleus and the vestibular portion of the auditory nucleus have been described. There is a great mass of clinical and direct experimental evidence for an intimate connection between the primary centres for the ampullæ of the internal ear and the oculomotor centres, particularly those for conjugate movements of the eyes in the horizontal plane. It is these horizontal motions which are shown by experiment to be most in need of compensation in order to avoid an underestimate of angular movements of the head due to the inertia of the eyeballs. It is significant in this connection that the abductors and adductors of the eyeball are in most intimate connection with the vestibular apparatus, according to the results of Duval and Laborde. The accompanying diagram from Bonnier illustrates a possible arrangement of these connections, though it should be remembered that they are all more or less in dispute (Fig. 1566). *C. Judson Herrick.*

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CREASOTE. See *Creosote.*

CREMATION. See *Dead Bodies, Disposal of.*

CREOLIN is a German proprietary article. Commercial creolin, however, varies much in appearance, and many preparations are sold under that title. The cresols form the active ingredients. The following analysis of the German compound is furnished by Dr. Bernard Fischer: Cresols, 20 parts, naphthalene, 18 parts; other hydrocarbons, 20 parts; and non-volatile matter, 42 parts. It is quite free from carbolic acid and other poisonous ingredients, and should not possess any toxic properties. Creolin is prepared by treating these insoluble hydrocarbons with resin and caustic potash, which form a resinous, soapy emulsion. When added to water and agitated the ingredients remain suspended as an emulsion. In appearance it is a dark, resinous liquid, neutral to test paper, not caustic. Its odor resembles that of creosote. It mixes with oils.

It is said to possess powerful antiseptic and disinfectant properties, and is recommended as a substitute for carbolic acid. It is very extensively employed, and numerous reports speak in its favor in all conditions in which carbolic acid is indicated.

For surgical purposes two solutions are employed, one containing two per cent. of the drug, the other one half per cent. The stronger is used for disinfecting the hands, the instruments, and surfaces of the body; the weaker solution is used for irrigation, moistening dressings, saturating tampons, etc.

For suppurating and sloughing wounds, and when discharges are offensive the parts may be cleansed and disinfected by the pure drug, and the effect maintained by a weaker solution. To irrigate the bladder, urethra, nose, pharynx, and other mucous surfaces, a solution of one part in a thousand is sufficiently strong.

The objections to its use are, the uncertainty of its action on account of the numerous preparations, and being unctuous it renders the hands and instruments slippery and difficult to handle. *Beaumont Small.*

CREOSIN is a clear yellow fluid of not unpleasant taste composed of creosote, iodine, calcium hypophosphite, and balsam of Peru. It is free from causticity or other unpleasant by-effects, its taste is not disagreeable, and it is freely miscible with wine, milk, or soup. It was introduced by Bosio as a useful method of administering creosote, and is used like it in phthisis, bronchitis, bronchiectasis, etc. *W. A. Bastedo.*

CREOSOTE.—The title *creosote* belongs to a product of distillation of wood-tar, and much confusion has arisen from its application also to certain products of distillation of coal-tar, as in the title *coal-tar creosote.* This confusion, furthermore, has been worse confounded by the too frequent commercial trick of selling the coal-tar product in substitution for the wood-tar *creosote* proper. True creosote is recognized by the United States Pharmacopœia under the title *Creosotum,* Creosote, and is defined to be "a mixture of phenols, chiefly guaiacol and creosol, obtained during the distillation of wood-tar, preferably of that derived from the beech."

Creosote is "an almost colorless, yellowish or pinkish, highly refractive, oily liquid, having a penetrating, smoky odor, and a burning, caustic taste; usually becoming darker in tint on exposure to light. Specific gravity not below 1.070 at 15° C. (59° F.). Soluble in about 150 parts of water at 15° C. (59° F.), but without forming a perfectly clear solution. With 120 parts of hot water it forms a clear liquid which on cooling becomes turbid from the separation of minute oily drops. . . . Soluble, in all proportions, in absolute alcohol, ether, chloroform, benzin, carbon disulphide, acetic acid, and fixed and volatile oils" (U. S. P.). A notable point of difference between creosote and carbolic acid is that creosote does not coagulate albumen or collodion, while carbolic acid does.

Creosote is closely related, chemically, to carbolic acid, and resembles that body in physiological properties. Creosote, however, while equalling carbolic acid in antiseptic power, is distinctly less poisonous to the animal economy. Because of this circumstance creosote has been used as an internal medicine in such diseases as pulmonary consumption, in the hope of arresting the morbid process through a poisoning, within the body of the patient, of the peccant micro-organism. But whatever good may result from the treatment, it is quite certain that, as creosote is used internally, it does not affect the vital endowments of the tubercle bacillus.

Creosote tends to allay reflex nausea and vomiting, and to benefit pulmonary catarrhs, in the stage of active secretion.

For ordinary purposes creosote is prescribed in doses of a few drops, to be taken preferably in capsule, and upon a *full* stomach. Considerable quantities, however, may be borne safely, and so much as several hundred drops has been given daily, and for months, in the treatment of phthisis. But such dosage must be reached gradually, and care should be taken that the sample is pure and derived from the beech.

In the event of poisoning by creosote, the soluble sulphates should be used as antidotes, as in poisoning by carbolic acid.

The United States Pharmacopœia makes official *Aqua Creosoti*, Creosote Water, a simple one-per-cent. solution of creosote in distilled water. *Edward Curtis.*

CREOSOTE, POISONING BY.—Poisoning by creosote has never become either popular or fashionable. The homicide and suicide have sought other means to attain their ends, and even "accident" and "negligence" have given creosote a wide berth. This prejudice against creosote exists on both sides of the Atlantic. Thus, in a table of about fifteen hundred deaths by poisoning occurring in the city of New York during the period 1841 to 1892, there are only two deaths from creosote, and both of them accidental (Witthaus and Becker's "Medical Jurisprudence, Forensic Medicine, and Toxicology"). And in England and Wales for a period of ten years (1883 to 1892) of 6,616 deaths from poison, only one was due to creosote, and this, too, was attributed to accident or negligence (Blyth, "Poisons"). Nor is it the general public and the criminals alone who thus ignore creosote; it is equally neglected by text-book writers. It is true that stray cases of poisoning by creosote are found in medical literature, but the text-books on poisoning and medical jurisprudence, as well as the medical dictionaries, as a rule, either omit the subject altogether or refer the reader to carbolic acid. The reason for this latter course is probably that creosote being a complex body, and its constituents varying so much and formerly containing an uncertain but fairly large quantity of phenol, it was difficult to pronounce on death caused by creosote. At the present day its composition is much more certain, and in medicine it is practically always "beechwood creosote" that is used; but as a set-off to this greater certainty must be added the fact that creosote is in great danger of being entirely replaced by phenol for external use, and internally by guaiacol.

Reports of Cases.—The following are the most important cases: 1. Given by Stevenson (Guy's Hosp. Rep., 1875). A woman in advanced state of pregnancy took an unknown quantity of creosote; whether homicide, suicide, or to produce abortion is not known. Unconsciousness and stertorous breathing soon supervened. She was given tartar emetic and salt, and emesis was slowly produced; vomitus was green, consisting of food, salt, and tartar emetic. Urine like milk and water and ink. Followed by speedy recovery and no signs of aborting.

2. Pürckhauer (Friedreich's *Blätter f. ger. Med.*, 1883) reports that a child ten days old took gtt. xxiv. to xxx. of creosote, became insensible, then convulsed, and finally died in sixteen hours.

3. Marcand's (*Vierteljahrsschr. f. ger. Med.*, 1889). An infant took an unknown quantity and died in fourteen hours with symptoms of irritant poisoning.

4. Freudenthal's (New York *Med. Rec.*, 1892), of an adult female who took gtt. cc., became unconscious, with stertorous breathing, and abolished reflexes, finally recovered. She had been in the habit of taking gtt. c. three times a day, and on this occasion took a double dose.

5. Zawidski (*Centralbl. f. innere Med.*, 1894) mentions the case of a woman, aged fifty-two, who took three six-drop doses of creosote in milk, toxic symptoms then developed, and she died five days after.

6. Cowan (Glasgow *Medical Journal*, 1897) reports that a girl aged three took an unknown quantity in toothache mixture. She suffered from abdominal pain, collapse, and in half an hour fell asleep nearly unconscious. Her stomach was washed out, she vomited two or three times, and was well in six days.

7. Wood reports the case of a woman who took gtt. dc. of creosote and became unconscious and cyanosed, but recovered without treatment.

Lethal Dose.—As individual tolerance for creosote varies, so does the amount required to produce toxic symptoms and fatal effect. The smallest quantity which has been reported as causing death is gtt. iij. to vi.; on the other hand, Wood's case took gtt. dc. and recovered without treatment. (For both these cases see above.) These are probably the extremes. Tolerance for creosote can be acquired; "♏ccc. a day have been given for a considerable time with benefit" (White, "Mat. Med. and Therap."). Graham (*Brit. Med. Journal*, 1898, i.) reports the case of a patient taking ♏ cccxl. every day, and suffering no ill effects therefrom. In the *American Year Book of Medicine and Surgery* for 1899 are quoted cases in which (1) ♏ cxx. were given daily; (2) ʒ iiiss. per day were administered in cod-liver oil, the patient becoming so impregnated with creosote that all the secretions and excretions had the odor of the drug; (3) the dose was increased up to 680 drops a day without causing any disturbance. The reason for these very excessive doses is not given, and it is certainly not apparent.

Symptoms.—Some persons are very sensitive to the action of creosote, and others are very tolerant of the drug; hence the factors to be always taken into consideration, are: the personal idiosyncrasy, the quantity of creosote taken, the rate at which the dose has been increased, and the rapidity of elimination by the kidneys. The symptoms, which may come on very rapidly, are nausea; vomiting, which is not regular and may be slight; severe abdominal pain, gastric disturbance, and purging; malaise; vertigo; headache; prostration; anxious expression; pinched face; subnormal temperature; skin cold and clammy, and covered with perspiration; depressed heart action, with pulse weak and thready or imperceptible; stertorous breathing; dyspnœa; dimness of vision, and contraction of pupils; tendency to stupor; abolition of reflexes; possible cyanosis. The urine may or may not have the odor of phenol; as to discoloration opinions differ. In Stevenson's case the urine was black; Mann ("Forensic Medicine") says creosote will not give a black color to urine; Ringer says the urine is discolored generally at first. It is rarely albuminous, and pigmentation, if present, is probably due to oxidation products of the phenol group. "The occasional smoky urine does not imply disintegration of blood corpuscles, as at one time supposed, but is the result of a harmless chemical reaction, and may be disregarded" (A. H. Smith, *Medical News*, 1899). If there are local symptoms they begin to manifest themselves at once; there may be pain in the region of the kidneys. "Death occurs from failure of respiration, and the heart is arrested in diastole" (*Sajous' Annual*, 1898).

Treatment.—In cases of *gradual* poisoning withdraw the drug; if urine becomes discolored or digestion disturbed reduce the dose. In *acute* cases wash out stomach, give doses of Epsom or Glauber's salt, and warm demulcent drinks; saccharate of lime (fresh quicklime 15 parts, sugar 25 parts, water 1,000 parts) is also beneficial; apply heat externally, and counter-irritation over abdomen; give respiratory and cardiac stimulants, strychnine and digitalis, and if necessary a hypodermic of ether.

Post-mortem Appearances.—Much the same as produced by phenol; there may be stains on skin, eschars on mouth or lips, erosions of mucous membrane of part of œsophagus or stomach, stomach may be red and injected, general inflammation of digestive tract, sometimes passive hyperæmia. These appearances are those of corrosion and vary according to the degree of concentration. The odor of creosote may or may not be present; in Pürckhauer's case it was present, in Marcand's it was absent.

Tests.—I. As for Carbolic Acid (see article on *Carbolic Acid, Poisoning by,* in Vol. II. of Reference Handbook).

II. A mixture containing carbolic acid, creosote, and cresol should first be subjected to fractional distillation.

III. Differences between carbolic acid and creosote.

1. Creosote is insoluble (or nearly so) in glycerin; carbolic acid is soluble in glycerin.

2. With collodion creosote mixes freely and does not coagulate; carbolic acid coagulates and becomes gelatinous.

3. With alcohol and ferric chloride creosote gives a green color; carbolic acid gives a brown or dark yellow.

4. If a chip of pine wood be placed in a distillate containing carbolic acid, and on removal be moistened with hydrochloric acid, it will get a blue color in about half an hour; with creosote there is no change of color.

R. J. E. Scott.

CRESALOL.—This is the cresylic ether of salicylic acid, and bears the same relation to creosol or cresylic acid that salol does to carbolic acid. It is analogous to betol and salol, and has been introduced by Nencki, the originator of the other two compounds. It is prepared by treating cresylate of sodium and salicylate of sodium with perchloride of phosphorus. Three salts are formed, according as the ortho-, meta-, or para-cresylic acid is present. All three possess the same properties, but the para-cresalol is the one usually prepared. The chemical formula is $C_6H_4OHCOC_6H_4CH_3$.

Cresalol is a white, crystalline powder, without taste; odor somewhat resembles salol. It is insoluble in water, slightly soluble in alcohol. The dose is given as from gr. iij. to xxx. daily. It possesses antiseptic properties similar to salol, and, like that salt, is not acted upon by the secretions of the stomach. It is used for intestinal antisepsis, and is said to be more efficient than its analogues. In the system it is decomposed into cresol or cresylic acid and salicylic acid, and its advantage lies in the freedom of these acids from any toxic properties.

Beaumont Small.

CRESOCHIN is a compound of chinolin and tricresol with neutral chinolin-tricresyl-sulfonate. It contains thirty per cent. of chinolin and seventy per cent. of tricresol, and is soluble in 20 parts of water. It is used in 0.1- to 0.2-per-cent. solution for disinfecting instruments and the hands, and as a vaginal douche.

W. A. Bastedo.

CRESOL, CRESYOL, CRESYLIC ACID.—Cresol consists of ortho-, meta-, and para-cresol in variable proportions, having a general formula of C_6H_4,CH_3,OH. Ortho- and para-cresol are crystalline bodies, and metacresol is a colorless, thick fluid. Their boiling points are respectively 188° C., 198° C., and 201° C., the similarity of which renders it difficult to separate them. It is the next higher homologue of carbolic acid or phenol, and differs from it by the replacing of one atom of hydrogen by the methyl group CH_3. It is present in coal tar, with carbolic acid, and is obtained during the process of fractional distillation. Up to 80° C. about four per cent. is separated, consisting of carbon bisulphide, ammonia, amylene, benzene, and other very volatile compounds. From 80° to 210° C. what is termed the light oil is removed; this is made up of benzene and its homologues. Between 210° and 400° C. the heavy oil is formed, consisting of phenol, naphthalene, cresols, and other hydrocarbons. The residue is pitch, about fifty per cent. The phenol, cresol, and naphthalene, and other constituents of the heavy oil, are separated by further distillation. It forms the greater part of the crude carbolic acids of commerce, which might more properly be called crude cresols.

It is a colorless, strongly refractive liquid, and is strongly caustic; its odor resembles that of creosote. It is insoluble in water, soluble in alcohol, glycerin, and ether. The cresols are powerful antiseptics and produce some of the most active preparations of the aromatic series. According to the investigations of Jaeger and Ohlmüller, of the Berlin Board of Health, and Fraenkel, of the Berlin Hygienic Institute, it has been shown that when dissolved in sulphuric acid the most active of such antiseptics is formed. Being insoluble in water it is difficult to obtain a solution that is stable and applicable to surgical purposes.

Many methods have been devised and numerous preparations have been introduced into commerce under a variety of names; creolin, lysol, solveol, solutol, and others, are all preparations of this kind. Some contain other hydrocarbons in addition to the cresols. Resin and alkali soaps form a favorite means of retaining the active ingredients in solution, but when added to water they produce milky and greasy fluids, very objectionable for surgical uses; the antiseptic properties are, however, effective as deodorizers and disinfectants. Cresotate of soda has been found to retain cresol in solution. For therapeutic purposes a one-and-one-half-per-cent. solution is sufficiently strong, free from irritant or caustic properties, and equal to a five-per-cent. solution of carbolic acid. Cresol is also dissolved in a concentrated solution of salicylate of sodium, which allows of free dilution; no decomposition occurs, a neutral solution of cresol being formed. Lime is recommended as a means of producing a solution which forms a cheap and active disinfectant; one part of lime is treated with four parts of water, and five parts of cresol are added; the resulting liquid contains fifty per cent. of cresol and is miscible in water in all proportions. A simple method of rendering cresol miscible with water is to add three parts of tincture of green soap. The mixture is at first cloudy from the presence of the water in the tincture, but after standing for twenty-four hours all the water settles at the bottom and can be separated.

For internal administration the preparation cresalol has been introduced and is highly recommended.

Beaumont Small.

CRESOTIC ACID. See *Salicylic Acid.*

CRESSON SPRINGS.—Cambria County, Pennsylvania.

Post-Office.—Cresson. Hotel and cottages.

Access.—Cresson is a station on the Pennsylvania Railroad, 250 miles west of Philadelphia and 102 miles east of Pittsburg. Through sleeping-car tickets may be purchased from all important points.

On the summit of the Alleghany Mountains, 2,300 feet above the sea level, is located the charming and picturesque resort known as Cresson Springs. This lovely spot has been abundantly endowed with nature's choice attractions, and it is at once a resting-place for the weary and a sanitarium for the weak in body. The bracing mountain air is in itself a speedy antidote to many of the lesser ills of life, and it is said that the early stages of pulmonary trouble are quickly arrested by a sojourn here. The Mountain House, adjoining the Springs, is a structure of imposing proportions and built with a special view to its fitness as a hotel. Its sanitary arrangements are excellent, and it is properly equipped with all the comforts, conveniences, and luxuries of the day. The building is located in an extensive park of magnificent forest trees. The grounds cover an area of 400 acres, much of which is devoted to lawn garden and groves. Adjacent to the hotel are a number of cottages, which may be rented by those who prefer a more home-like seclusion than is attainable in a large hotel. The hotel and its surroundings furnish ample scope for amusement and diversion. Lawn-tennis, croquet, rambles through the woods and mountains, and driving are among its outdoor diversions. During the season daily observation cars are run between Cresson and Altoona, and several times each week between Cresson and Ebensburg, affording to excursionists some of the finest mountain scenery in the country. The romantic beauty of the famous Horseshoe Curve, the inspiring grandeur of the Old Portage Road, the wild charm of the Allegrippus, and the endless vistas formed of forest-crowned peaks and leafy valleys excite the admiration of every lover of nature. Two of the springs at Cresson have been analyzed by Prof. F. A. Genth, of the University of Pennsylvania, with the following results:

MAGNESIA SPRING.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium sulphate	0.11
Magnesium chloride	.56
Calcium chloride	1.30
Sodium chloride	1.23
Iron bicarbonate	.02
Manganese bicarbonate	Trace.
Magnesium bicarbonate	.41
Calcium bicarbonate	.02
Sodium bicarbonate	1.43
Potassium bicarbonate	.21
Calcium phosphate	Trace.
Alumina	Trace.
Silicic acid	.91
Nitrous acid	Trace.
Carbonic acid (free)	.66
Total	6.86

This water is somewhat aperient in full doses. It also possesses reconstructive and tonic properties.

PURE SPRING.

Solids.	Grains.
Calcium sulphate	0.04
Calcium carbonate	.35
Magnesium carbonate	.24
Iron carbonate	.02
Sodium carbonate	.12
Potassium carbonate	.08
Sodium chloride	.16
Silica	.25
Phosphoric acid	Trace.
Manganese oxide	Trace.
Total	1.26
Carbonic acid (free and partially combined)	1.40

This spring is entirely free from organic matter. It emerges in considerable volume from a group of crushed strata formed almost exclusively of silicious elements. It is but slightly mineralized, however, and may be referred to the indifferent group of waters.

James K. Crook.

CRETINISM. See *Goitre.*

CROCKER SPRINGS.—(Formerly White Creek Springs.) Davidson County, Tennessee.

POST-OFFICE.—Cole Building, Nashville, care of A. G. Goodlet.

Hotel destroyed by fire, but there are accommodations for a few visitors.

This resort is situated 12 miles west of Nashville, at the foot of a high plateau running north from the Cumberland River to the Kentucky line. The altitude is about 600 feet above the sea level. The surrounding country is broken, the springs being situated between high hills. The large hotel was destroyed by fire some years since, so that the present accommodations are not what may usually be expected at first-class watering-places. There are, however, several comfortable buildings for the reception of guests. Adjoining the springs is a tract of 200 acres, containing fine orchards of apple, pear, and peach trees, etc. The prevailing meteorological conditions are clear weather and sunny days, with an atmosphere free from malarial or miasmatic influences. Two springs are in use, one known as the "Black Sulphur," temperature 58° F.; and the other as the "Red Sulphur," temperature 56° F. The following analysis was made many years ago (1841) by Dr. Troost, analytical chemist:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	35.42
Sodium sulphate	13.20
Calcium sulphate	19.64
Magnesium sulphate	19.32
Sodium hyposulphate	6.50
Total	94.08

Gases.	Cubic inches.
Carbonic acid	37.99
Sulphureted hydrogen	40.25

These waters have been well known in Tennessee for their beneficial effects in hepatic congestion, indigestion, Bright's disease, and the uric-acid diathesis.

Within two or three hundred yards of the building is a cold limestone spring which flows from a cave having a remarkably low temperature. The cave is utilized as a natural cold-storage house. *James K. Crook.*

CROCKETT ARSENIC-LITHIA SPRINGS.—Montgomery County, Virginia.

POST-OFFICE.—Shawsville. Hotel.

ACCESS.—Via Norfolk & Western Railroad to Shawsville, thence 7 miles to springs by carriage.

This resort is located in the Alleghany Mountains, 3 miles from the Alleghany Springs. The elevation is 2,000 feet above the sea level, and the atmosphere pure, bracing, and delightful. The hotel is a new and substantial structure of artistic design, with a veranda encircling the main building, and is fitted up with modern conveniences. Ample provision has been made for the entertainment of guests. There are bowling alleys, lawn tennis courts, and croquet grounds. Walks, drives, fishing, and hunting are also enjoyed, while many find pleasure in rambling through the woods to the famous falls, where a bold and sparkling stream leaps for hundreds of feet from rocks and precipices, forming cascades and sprays of great beauty. The scenery about the resort is romantic and picturesque and affords ever varying features to charm the visitor's eye. The waters of the Crockett Springs are close to thermal, having a temperature of 70° F. in the coldest winter months. The following analysis was made a few years since by Prof. Henry Froehling:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium carbonate	1.18
Calcium carbonate	5.90
Strontium carbonate	.09
Lithium carbonate	.07
Magnesium sulphate	3.04
Calcium sulphate	2.25
Potassium sulphate	1.25
Iron sulphate	.04
Sodium sulphate	1.86
Sodium chloride	1.23
Sodium bromide	.01
Sodium arseniate	.02
Aluminum silicate	.12
Silicic acid	1.29
Barium carbonate, copper carbonate, lead carbonate, zinc carbonate, manganese carbonate, sodium iodide, aluminum phosphate, and ammonium nitrate	Traces.
Total	18.35
Carbonic anhydride combined with monocarbonates to form bicarbonate	3.23
Total	21.58

This water is more distinguished for the variety than for the quantity of its mineral ingredients, yet some of its constituents, though minute in quantity, undoubtedly impart to the water an appreciable therapeutic value. It is said that the well-known physiological effects of arsenic, for example, may be readily produced by taking the water in large quantities. In practice the water has been shown to act as an eliminating agent, a nerve sedative, a nerve and blood tonic, and also as an alterative. It has been found particularly valuable in the chronic types of skin disease, especially those characterized by scaly eruptions. In those varied conditions in which arsenic is useful the water meets the indications perhaps more promptly, with more permanent results, and with less constitutional and local irritation, than do the artificial preparations of arsenic. The hotel is amply supplied with bathing facilities at any temperature, and good results have followed the conjoint use of the baths and the internal administration of the water. An office has been fitted up for the resident physician by the management, with the latest and most improved electrical apparatus and other appliances for the treatment of chronic diseases. The water is used commercially.

James K. Crook.

CROTON OIL.—Oleum Tiglii. Oleum Crotonis. "A fixed oil expressed from the seed of *Croton Tiglium* L. (fam. *Euphorbiaceæ*)" (U. S. P.). This species of croton is a small, slender-branched tree, native of China, but very largely cultivated in India, and abounding in the East India Islands. The fruit is a three-celled, three-seeded capsule. The seeds are about 1 cm. long, oblong, rounded on the back, slightly flattened on the face on each side of the median line, where the raised raphe is to be seen running from end to end. Color of seeds yellowish-brown, black where the outer layer is scraped off, not shining. Testa brittle. Embryo large, albumen oily. In structure and shape they are very much like castor-oil seeds. They are much more uniform in size than the latter, larger than the smallest, smaller than the largest. Taste at first oily, then acrid.

The seeds are used in Java for poisoning fish. They are also largely used in Hindoo medicine, but it is directed that the membrane (tegmen) as well as the testa, and also the embryo, shall be first removed. Besides the oil, they contain *crotin*, a highly poisonous toxalbumin, similar to the ricin of castor-oil seeds. The yield of croton oil is about one-fourth to one-third the weight of the seeds. It can be removed with ether or other solvents, though the official requirement is that it be expressed.

Both the seeds and oil are imported from Bombay, Cochin, etc.; the oil is also expressed in Great Britain from seeds imported from the East.

The oil is thus described:

"A pale yellow or brownish-yellow, somewhat viscid, and slightly fluorescent liquid, having a slight, fatty odor, and a mild, oily, afterward acrid and burning taste (*great caution is necessary in tasting*).

"When applied to the skin, it produces rubefaction or a pustular eruption.

"Specific gravity: 0.940 to 0.960 at 15° C. (59° F.).

"It reddens blue litmus paper moistened with alcohol.

"When fresh, it is soluble in about 60 parts of alcohol, the solubility increasing by age.

"It is freely soluble in ether, chloroform, carbon disulphide, and in fixed or volatile oils.

"When gently heated with twice its volume of absolute alcohol, it forms a clear solution from which the oil usually separates on cooling.

"If to 2 c.c. of the oil 1 c.c. of fuming nitric acid and 1 c.c. of water be added, and the mixture vigorously shaken, it should not solidify, either completely or partially, after standing for one or two days (absence of *other non-drying oils*)."

Composition.—This is one of the most complex of fixed oils in composition, and notwithstanding the very extensive study to which it has been subjected, our conclusions are yet far from satisfactory. It dissolves in an equal amount of alcohol, but if this volume of alcohol is increased a portion is insoluble. It is again soluble in 60 parts of alcohol. As the oil becomes older its solubility in alcohol increases, and, *pari passu*, its irritating properties increase. The most important fact, practically, is that it consists chiefly of a glyceride of crotonoleic acid. This body is purgative, whether in its own state or, as most likely, only through the gradual setting free of the acid in the intestine, is not certainly known. The acid is freely soluble in alcohol, and can thus be removed from croton oil, which always contains some in a free state. It is extremely irritating to the skin and mucous membrane, and it is its gradual formation by decomposition on keeping which renders the older oil more vesicant and more violently drastic. This acid is in a general way similar to ricinioleic acid of castor oil, but is much more active. Glycerides of several other acids, fixed and volatile, have been reported. It is believed that irritating properties reside in some one or more of these volatile constituents, as employees in the factories who do not come into contact with the oil suffer from cutaneous irritation.

Action and Uses.—From the above, it will be seen that croton oil is (1) a vesicatory and (2) a drastic purgative. Upon the skin, a drop to each twenty or thirty square inches produces violent irritation, usually an acute eczematous eruption of numerous closely aggregated blisters, becoming, if the result is intense enough, pustular and scabby. The eruption is usually limited to the region to which the application is made, but in extremely susceptible patients a general vesication of nearly the whole body may follow a limited application. It has been a moderately common mode of counter-irritation in bronchitis and other diseases, but is now only rarely used. It has also been used as a parasiticide in obstinate cases. Absorption and purgation have frequently followed its external application.

As a quick purgative, where the most rapid and complete emptying of the bowels is required, in "congestive" and other apoplexies, in injuries to the head, in uræmic conditions, in short, whenever an intense derivative action to the bowels is required, croton oil was for a long time at the head of the list; its rapidity and the smallness of its dose being great advantages. With the multiplication of purgatives, however, the objectionable features of this oil have led to a steady decline in its use. This is now more generally confined to cases absolutely requiring a powerful local action upon the intestine, such as lead colic or seasickness, or to those in which other purgatives cannot be readily administered, as to those individuals who are in a state of insensibility, or to insane patients. Here the dose can be made effective by simply dropping it upon the back of the tongue. The purgative action of this drug is essentially an irritative one, accompanied by griping pain, and often followed by much inflammation. There is increase of watery secretion and also of motion, and any abdominal or rectal irritation or inflammation is markedly increased. It also irritates the uterus, and is abortifacient. These effects may be moderated by washing it with a little alcohol, and thus removing the free crotonoleic acid. The dose is ♏i. to ij., and should not be repeated.

Poisonous symptoms are commonly those of great abdominal inflammation, followed by depression or collapse. In some cases, when purging has not occurred, great depression and progressive blunting of the vital powers have been observed, as is common in the lower animals.

Henry H. Rusby.

CROUP.—Croup is an acute inflammation of the larynx, characterized by the formation of a pseudo-membrane. The principal symptom from which the disease derives its name is a peculiar crowing cough. A similar cough is also found in severe cases of acute laryngitis in children and in laryngismus stridulus; consequently these last two diseases are frequently included under the heading of "croup," although in them there is no formation of a false membrane in the larynx.

Etiology.—In the great majority of cases the false membrane is due to the action of the Klebs-Löffler bacilli, thereby making croup one of the manifestations of diphtheria, that is, of laryngeal diphtheria (see *Diphtheria*).

Billings, after careful bacteriological investigation of two hundred and eighty-six cases of membranous laryngitis, found Klebs-Löffler bacilli in eighty per cent. of them; streptococci and diplococci were the bacteria found in the remaining twenty per cent. of the cases.

The idea prevalent some years ago, that much of the croup was idiopathic and non-diphtheritic in its character, in the last decade has been shown to be false and it is now an established fact that a very large percentage of these cases are diphtheritic.

Non-diphtheritic membranous laryngitis, or false croup, as it is often called, may result from blows upon the larynx, from the inhalation of hot steam and smoke, or from the introduction into the larynx of caustic alkalies or acids.

Pathology.—In the early stages the laryngeal mucous membrane is hyperæmic, while later there is a round-cell infiltration into the epithelial and subepithelial layers, followed by a transudation of lymph into these infiltrated regions. The lymph coagulates, and the action of the toxins developed by the bacilli produces a coagulation necrosis of the cells, first of the epithelial layer, subsequently of the subepithelial, and this necrosis of the cells results in the so-called false membrane. At first this membrane is firmly bound to the underlying tissues by the fibrin and the coagulated lymph, so that any attempt forcibly to remove the membrane results in hemorrhage. The subsequent changes are those of still further necrosis of these areas, a line of demarcation being formed where the cells undergo liquefaction and the fibrin breaks up. By such a melting process the membrane is gradually exfoliated; or else at some point it curls up and then, in a violent fit of coughing, is torn off and expelled as a single mass.

The color of the exudate at first is a dirty gray, but where the infection is very severe, involving the larger blood-vessels deep down in the subepithelial layer, a condition allied to gangrene supervenes and the exudate may be dark green or even black.

The places where the exudation is commonly found are the ventricular bands or false vocal cords, the true vocal cords, the posterior wall of the larynx, the trachea, and in severe cases, even the bronchi.

Symptoms.—The symptoms of croup usually are superimposed upon those of diphtheria, and it is rare that a patient has the laryngeal type at the onset of the disease. It will be found, as a rule, that the patient has had sore throat, nausea, perhaps vomiting, a slight rise in temperature, and a pulse somewhat accelerated for two or three days before the first evidence of laryngeal involvement is observed. There does not seem to be any definite relation between the severity or the mildness of the diphtheritic process and the tendency to involvement of the larynx. The mildest forms of pharyngeal diphtheria are sometimes complicated with croup, and the severest forms of faucial diphtheria are found without this complication.

The first indication of the involvement of the larynx that is likely to be observed is a hoarseness of the voice. This may persist for a few hours or even for a day or two before it will be observed that the patient has some difficulty in breathing; this difficulty is usually more marked during inspiration than it is during the expiratory stage. Once the dyspnœa manifests itself it is usually steadily progressive, sometimes at an alarming rate, and the cough becomes of a peculiar crowing character with numerous short expiratory coughs followed by one long, crowing inspiratory effort, the "croup," which gives the name to the disease. These paroxysms at first may not be very severe nor more frequent than once in every three or four hours; they soon, however, become more frequent and more severe. During each paroxysm the face becomes first deeply congested and later cyanotic. The paroxysms leave the patient quite exhausted. It is not uncommon for him to fall into a profound sleep in the intervals between the paroxysms, during which time the breathing is labored. As the laryngeal obstruction and the paroxysms become more severe the patient frequently has convulsions, during which the urine and fæces may be involuntarily voided. Death occurs most frequently either from exhaustion, from asphyxia, or from heart failure. In one of the severe paroxysms when it would seem as if the end were about to come, it occasionally happens that the membrane, a cast of the larynx, will be expelled at the end of the paroxysm. The patient then falls into a quiet sleep, the breathing becomes normal or nearly so, and recovery takes place. In exceptional cases, in which the membrane is moderate in amount and the paroxysms are not too severe, and the patient has a considerable amount of vitality, the membrane may gradually melt away, the paroxysms by degrees becoming less and less severe, and recovery taking place in this gradual manner.

The examination of the upper air passages in a patient suffering from croup almost invariably reveals evidences of membrane formation either on the tonsils, the pillars of the fauces, or the posterior pharyngeal wall, or in the nasal channels or the nasopharynx.

Bacteriological examination as to the character of this exudate furnishes us with a clew as to the probable nature of the bacilli connected with the membrane formation in the larynx.

Diagnosis.—Croup may be mistaken for acute laryngitis, for laryngismus stridulus, or for œdema glottidis.

Croup is to be distinguished from the *acute form of laryngitis* by the facts that the latter disease is usually associated with an acute bronchitis, that the attacks are most frequent at night time, that the paroxysms are not so severe as in true croup, and that the child is usually free from all croupy symptoms during the day, only to be affected again the following night. It will often be found that every attack of acute laryngitis and bronchitis is accompanied by some croupy cough and that antispasmodics and emetics give rapid relief from the croupy symptoms of acute laryngitis while ordinarily not affecting the paroxysms of true croup.

Laryngismus Stridulus is a spasmodic contraction of the adductors of the vocal cords, occurring in children of an exceedingly nervous temperament who have otherwise been perfectly well and free from all evidences of laryngitis. The attack comes on suddenly at night. The mother being wakened by a long, crowing inspiration of the child, rushes to the bed and usually finds the little one tossing about, the face congested, the arms wildly thrown about, the knees drawn up, and the urine and fæces often involuntarily voided. And then, when to all appearances it is about to die from suffocation, the child takes a deep inspiration, the body relaxes, the cyanosis disappears, and the child falls into a quiet sleep without any further spasmodic breathing. The child suffers neither from hoarseness nor from cough on the following day.

Œdema Glottidis is an affection of the larynx due to œdematous infiltration into the tissues above the vocal cords, and may be either acute, as in erysipelas, peritonsillar abscess, and wounds of the larynx, or more chronic as in tuberculosis, syphilis, and malignant disease of the larynx. It is far more common in adults than in children, is rather sudden in its onset in the acute variety, and the dyspnœa is inspiratory in character. Furthermore, *the voice is usually not affected*, whereas in croup progressive hoarseness and aphonia may be expected. The temperature will be little or much elevated, according to the disease which œdema of the larynx complicates; and finally a laryngoscopic examination will reveal enormously swollen, œdematously infiltrated epiglottis, aryepiglottic folds, and ventricular bands. In acute laryngitis, in laryngismus stridulus, or in œdema glottidis there will be no evidences in the throat of any membranous exudate, as will usually be the case in true croup.

Prognosis.—Croup is one of the most fatal diseases of childhood. The mortality will range anywhere from fifteen per cent. in epidemics of a mild form of diphtheria, to eighty per cent. in the severer types. The younger the patient, the greater, as a general rule, is the mortality rate. The earlier the larynx is involved in a case of faucial diphtheria, the more severe the disease and less favorable the prognosis, as a usual thing. When the trachea as well as the larynx is extensively implicated in the membrane formation the prognosis is exceedingly grave. When laryngeal diphtheria complicates measles, scarlet fever, whooping-cough, or any of the exanthemata, and when it occurs in rachitic or other poorly nourished children, the prognosis is exceedingly unfavorable.

Treatment.—The treatment of croup may be divided into the prophylactic, the hygienic, the constitutional, and the local.

1. *Prophylactic.*—Every child suffering from croup, even though the inspection of the fauces and bacteriological examination of the buccal cavity and its secretion may not reveal the presence of the Klebs-Löffler bacilli, should be carefully isolated. Small squares of cheesecloth should be employed in place of handkerchiefs for wiping the nose and catching any of the buccal secretion. These pieces of cloth should be immediately burned, or when this is impossible, they should be placed in a porcelain receptacle in which there is kept a solution of bichloride of mercury, 1 to 1,000. All clothing and bedding

material should be washed out in a bichloride solution of the same strength, and when this is impracticable, as in the case of mattresses, blankets, and similar articles, they should be sent away to some disinfecting plant where they may be carefully disinfected with formalin gas, superheated steam, or superheated air. The room in which the patient is to remain should be stripped of all curtains, carpets, and upholstered furniture, pictures, etc., which may be the means of retaining the germs and communicating them to others.

2. *Hygienic.*—The temperature of the room should be kept constantly at 75° F., and it is desirable that the air in the room be kept rather moist by means of a kettle of water kept boiling within it.

The diet should be of the most nourishing variety, preferably fluid. Milk in some form, either plain or diluted with lime water or Vichy; koumyss, matzoon, or buttermilk may alternate with the above for sake of variety. The white of an egg beaten up in half a glass of water may also be given in place of any of the above.

The room should be carefully ventilated from time to time, great care being taken that no draught shall strike the patient during the process.

3. *Constitutional.*—Since the introduction of antitoxin in 1894, for the treatment of diphtheria, and its almost universal employment with beneficial results and a great lowering of the mortality rate of diphtheria, especially the laryngeal type, or croup, we feel constrained to place this remedy at the head of the list. To be of the greatest service the antitoxin should be administered as early as possible in the course of the disease. We have, however, seen most beneficial results follow its employment even as late as the fifth day of the disease. In a case of moderate severity 1,500 units should be administered hypodermatically when the physician is first called to see the patient. If at the end of twenty-four hours there is not some improvement, the same amount should again be administered. In the severe types of the disease 2,000 to 3,000 units may be given at the first injection. While it is desirable that a regular antitoxin syringe be employed, an ordinary hypodermic syringe properly sterilized will answer the purpose.

It is always well to administer calomel as a purgative at the onset of the disease, and for this purpose gr. $\frac{1}{10}$ triturates of calomel should be administered, one every half hour until eight are taken. If at the end of the next six hours there has been no stool, it is desirable to give a saline laxative, such as citrate of magnesia (a tumblerful), in order to hasten the action of the calomel.

The administration of emetics, as ipecac, tartar emetic and the like, which were so much prescribed in former years for the purpose of loosening the membrane and enabling it to be expelled in the process of vomiting, almost never accomplishes this purpose and only serves to weaken the child and so prevent recovery.

Many physicians administer internally gr. $\frac{1}{100}$ of bichloride of mercury three times a day, claiming thereby that the action of the mercury tends to limit the formation of the membrane. I can see no objection to this method of treatment, but since the advent of antitoxin the latter has superseded the mercurial treatment.

4. *Local.*—The local treatment should consist in placing the child under a tent improvised by a sheet or blanket stretched over the bed. A piece of rubber hose attached to the spout of a tea kettle containing boiling water should lead under the tent and at a distance of six or eight inches from the patient's face, so that the escaping steam may not scald the patient. The inhalation of this hot, moist air will undoubtedly assist in the separation of the membrane and hasten exfoliation.

In mild cases the above constitutional and this local treatment may be all that will be necessary to carry the patient past the period when obstruction to respiration is most marked, and to avert the danger of impending asphyxiation; but in severe cases in which the exudate is very thick and the space in the larynx through which the patient can breathe is exceedingly narrowed; in which dyspnœa becomes very great and the breathing excessively labored; in which there is a noticeable degree of sinking-in of the soft parts above the clavicles; and in which, finally, an examination of the chest reveals imperfect expansion of the lungs, as shown by the feeble respiratory murmur, especially at the bases of the lungs posteriorly, it then becomes necessary to devise some means of furnishing the patient with an increased supply of air. Formerly tracheotomy was the only means that the physician had at his command for accomplishing this purpose; at the present time, however, owing to the very valuable service rendered to humanity by the late Joseph O'Dwyer of New York City, the intubation tubes have almost completely replaced the tracheotomy tubes as a means of affording an increased amount of air to the suffocating child.

Intubation should not be delayed until the child becomes cyanotic or exhausted from severe dyspnœa. (For method of intubating, see *Intubation.*)

The tube should be worn for a period of from two to seven days, according to the length of time that has elapsed from the onset of the croupy symptoms to the time of intubation. When intubation is done on the first or second day after involvement of the larynx the tube should be left in for five or six days; when intubation is performed on the fifth or sixth day of laryngeal diphtheria, it may be only necessary to leave the tube *in situ* for two or three days.

Great care should be taken in feeding the patient, liquids alone being employed. I have found it most practical to feed the child from a teaspoon, the nurse holding the child on her lap face upward and having the head markedly extended backward, the head thus being much lower than the rest of the body.

Occasionally intubation may not afford the needed relief, owing possibly to the physician's inability to introduce the intubation tube, or more likely to the pushing down of the membrane in front of the lower end of the tube. In such cases tracheotomy is imperative.

Cornelius G. Coakley.

CRUCIFERÆ.—(*The Mustard Family.*) A family of more than two hundred genera and probably fifteen hundred species, growing mostly in warm-temperate regions and widely distributed, many of them as common weeds. The family is of great economic importance, yielding the important food plants: cabbage, turnip, cauliflower, kale, sprouts, broccoli, and cresses of various sorts, and the important fixed oils of mustard, rape, and colsi. The important medicinal constituents are a series of glucosides similar to sinigrin, which in decomposing yield volatile principles of which the volatile oil of mustard is the type, consisting of aromatic compounds similar to those of onion and garlic. The counter-irritant and antiscorbutic properties of these oils will be described under *Mustard* and *Horseradish.* Quite a number of species, by virtue of these constituents, have been used as vulneraries. Such are the Shepherd's Purse (*Bursa Bursa-pastoris* [L.] Britton), and various species of *Lepidium*, *Barbarea*, *Sisymbrium*, and *Brassica.* They apparently possess a germicidal and disinfectant power, and at the same time stimulate healing of the tissues. They are from time to time recommended in the medical press as new remedies for application to wounds and unhealthy sores.

Henry H. Rusby.

CRUM MINERAL SPRINGS.—Mahoning County, Ohio.

POST-OFFICE.—Girard.

ACCESS.—Street railroad passes within one mile and a quarter of the springs.

These springs are located within 4 miles of Youngstown, Mahoning County, and about a mile and a half from Mineral Ridge, Trumbull County. No hotel has yet been built, but the water has been used commercially for the past seven years. The surroundings are said to be very attractive and well adapted for a summer resort.

The springs are four in number; only one, however, is in use. The following analysis was made by S. W. McKeown, analytical chemist:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	5.31
Magnesium carbonate	1.80
Iron carbonate	.59
Sodium carbonate	.14
Magnesium sulphate	1.17
Sodium chloride	.48
Silica	.29
Total	9.78

This analysis shows a combination of very useful ingredients. They give the water the properites of a ferruginous tonic, a mild diuretic, an antacid, and in large doses, a light laxative. The water is useful in disordered states of the stomach and in functional affections of the liver and bowels. Its continuous use tends to overcome chronic constipation. *James K. Crook.*

CRURIN. — Quinoline-bismuth-sulphocyanate. This is a coarsely granular, yellowish-red powder of pungent odor, insoluble in water, alcohol, or ether. It is decomposed on prolonged exposure to cold water and on boiling with dilute acids or alkalies. Steiner made extensive use of it in ulcers, especially those of syphilitic origin, by dusting the ulcer twice daily and covering with a protective dressing. It sometimes causes at first a burning pain, which is soon followed, however, by a feeling of warmth and comfort. If too irritating it may be diluted with starch. If the ulcers are old and have thickened edges, a wet dressing of aluminum acetate will soften them. Steiner found that both syphilitic and nonsyphilitic ulcers healed completly in from ten days to six weeks, under the use of this remedy. *W. A. Bastedo.*

CRYING is an involuntary disturbance of respiration accompanied by relaxation of the facial and jaw muscles and lachrymation; it is usually an expression of strong emotion, such as grief, fear, anger, or pain. The inspiration is short and deep, sometimes spasmodic in character; the expiration is prolonged; the glottis is narrowed and an inarticulate sound is usually produced. The eyes are generally closed, and the angles of the mouth are depressed.

Crying is the only language of the new-born babe, its only means of expressing its desires, discomfort, or dissatisfaction with its surroundings. The first welcome cry expands the lungs and probably assists in establishing the normal course of the circulation. The lustiness of it is taken as a measure of the infant's vigor. The cry of the infant differs, however, to some extent from that of the adult, in the facial expression, in the absence of tears, and in the sound produced. The eyes are closed, the mouth is widely opened, the chin often quivers. With the development of the lachrymal and salivary glands, however, we have, by the third or fourth month, a flow of tears and often drivelling.

Physiology.—In crying the diaphragm is suddenly deeply depressed, causing full inspiration. The action is involuntary and is so quick that the other respiratory muscles probably take little or no part in it. The ascent of the diaphragm may be uniform or interrupted, and the air is forced through a partially closed glottis, producing a steady or a broken, inarticulate sound, varying, as a rule, with the character of the lamentation. The inspiration is sometimes also intonated (the "reprise"). The contraction of the laryngeal muscles sometimes becomes clonic and painful in the prolonged crying of deep distress. The circulation is accelerated; the face and even the entire integument of the young infant may become engorged with blood. Although the act is involuntary, it may be closely simulated, and it may be voluntarily arrested. The nervous mechanism of crying is not fully understood. It is closely related to that of laughing, so closely, in fact, that in children and hysterical adults either may quickly give place to the other. Crying may be inaudible when, from embarrassed respiration as in the weakness of marasmus, syphilis, rachitis, or pneumonia, the infant cannot produce the sound, or when, on account of pain, it suppresses it, as in pleurisy. The deepest grief is often expressed in silence, the face buried in the hands, perhaps, while the tears refuse to flow. Tearless crying in an infant more than four months old is regarded as an unfavorable symptom.

Significance of Crying.—Much may be learned of an infant's condition by observing its expression and its actions while crying, as well as from the character of the act itself, but it is going a step too far to say that the location of the disease can always be determined from the cry. Persistent crying always indicates the existence of something abnormal. It may denote hunger, as the mother is apt to believe; it is probably just as often a sign of thirst. If, however, the infant refuses to take the breast, this element is ruled out, providing there be no other cause for refusal, such as obstruction of the nostrils or disease of the mouth or throat. The cry of hunger is fretful, and is generally interrupted by vigorous sucking of the fingers or hunting for the breast, but the discomfort induced by overfeeding is manifested in the same manner. Nursing relieves hunger, but stops the cry of overfeeding only for the moment. In pain about the head the brows are generally knit and the hands are often raised to the region of the pain. In earache the cry is most persistent, and the hands may be held to the side of the head or thrust into the mouth, as is often the case also in disease of the mouth or throat. The sudden, sharp, hydrocephalic cry is characteristic of cerebral disease, but only in the presence of other symptoms. In painful diseases of the chest the cry is not loud, as a rule; it is more frequenly moaning in character, or each expiration may be slightly intonated. When coughing is accompanied or followed by crying it arouses suspicion that the bronchitis has reached the smaller tubes and that catarrhal pneumonia is imminent. The absence of crying is often of greater significance. The cry of weakness is low in tone, and has more the character of whining or moaning; it is often indicative of marasmus, atelectasis, or of hereditary syphilis when it has also a nasal tone. A hoarse cry denotes a catarrhal condition of the larynx which may be due to "cold," syphilis, diphtheria, or pseudo-croup. The "croupy" cry, with corresponding cough, signifies a dry or inflamed condition of the vocal cords or a spasmodic closure of the glottis as in laryngismus stridulus. In abdominal pain the crying is usually accompanied by squirming movements of the body and by drawing up of the legs or kicking. It ceases with the evacuation of the bowels in catarrh of the small intestine, but accompanies and follows it in colitis or dysentery. Laying the infant upon its abdomen stops it, not by relieving the pain, but by so impeding the respiration that it cannot cry. When continuous crying is unaccompanied by other symptoms of illness, errors may often be avoided by the removal of all clothing in order to exclude such causes as the pricking of a pin, inflammation about the umbilicus, or a recently developed hernia, dislocation, or fracture. The infant with rheumatism or pleurisy, and not infrequently the rachitic child, cries with pain when it is picked up; pressure upon different regions in succession will generally locate the tenderness.

In older children the manner of crying is often an index to the emotion expressed. In the cry of fear, for example, the eyes remain open and the orbits are turned toward the source of danger; the lips and often the entire face become pale; the outcry is short and loud. The cry of anger is also loud, but the lower lip protrudes in a pout, and the face becomes livid. The peevish cry of the spoiled child is accompanied by peeping eyes, a scarcity of tears, and whining often breaking into a staccato movement. The cry of pain corresponds to the character of the pain and varies from a sudden violent scream to a whine more like that of peevishness. In anger or pain the breath is often held until the face becomes cyanotic and the veins become distended. Convulsions have followed such paroxysms, and death has been attributed to them in a few instances. Such results would probably more frequently follow were it not for the anatomical peculiarities of the infant's circulation which permit the distention of superficial vessels and the more rapid flow of venous blood from the cranium. Finally, crying often becomes a habit with over-indulged children. Even young infants learn it and cry not merely for food or drink, but to be carried, to be rocked, for the light, or apparently for no other purpose than to attract attention. It is easily cured by persistent and total disregard of it on the part of the nurse.

Crying has also its significance in the adult, but much depends upon the emotional nature of the individual. Some persons maintain a stoical indifference to the most trying circumstances, while others are moved to tears by the merest trifles. The latter class are especially susceptible to the influence of suggestion. Crying frequently occurs in intoxication by alcohol and other stimulants, especially in advanced dypsomania. In the morphine habitué when frequent, it is sometimes indicative of the approach of imbecility. The weeping of the hysterical woman is characteristic in the depth of grief expressed, in the violence of the outcry, or its dramatic pathos, and especially in its sudden change to an equally violent fit of laughter. Crying is often a symptom of neurasthenia. In paralytic dementia and other forms of emotional insanity a tendency to weep is sometimes one of the earliest symptoms, and in the closing period of the disease it may often be induced by the most trivial circumstances, the asking of a question, or a mere glance at the patient. Many other diseases not necessarily involving the mind are attended by so great depression of spirit as to render it of frequent occurrence. Not infrequently, however, temporary improvement seems to follow a good fit of crying just as it often follows hearty laughter.

James M. French.

CUBA.—Cuba was discovered by Columbus on October 28th, 1492, and was called by him Juana, in honor of Prince Juan, son of Ferdinand and Isabella. Its present name is that by which it was known among the natives at the time of the discovery.

Geography.—The island of Cuba is very long and narrow, and lies between the 74° and 84° of west longitude and the 19° and 23° of north latitude. Its average breadth is about 80 miles. Nowhere is it more than 100 miles wide, and in the longitude of Havana it is less than 20 miles from sea to sea. Its length is about eight times its average breadth. Its extreme length, measured along a curved line following its centre, from Cape Maisi, in the east, to Cape San Antonio, in the west, is about 730 miles. The area of Cuba, including its adjacent keys and islands, is estimated at 45,000 square miles, a little less than that of the State of New York. The coast is very extensive, nearly 2,000 miles, and is surrounded by numerous small islands and reefs. In most places the coast rises abruptly from the sea. The principal exception is found in the great Zapata swamp on the south central coast. A number of good harbors indent the shore. The natural drainage of the island, as a whole, is excellent. The highest part of Cuba is a range of mountains known as the Sierra Maestra, bordering the southeast coast from Cape Maisi to Cape Cruz. The highest peaks of this range are the Pico de Turquino, 7,670 feet, the highest point in the island; Gran Pedra, 5,200 feet; Yunque, and Ojo del Toro, 3,000 feet above the level of the sea. From this range there extends very nearly through the centre of the island a general ridge, or range of hills, of greater or less elevation. In the extreme western part of the island, this ridge again attains considerable height in the Pan de Guajaibon, which is 2,530 feet above the sea. The island is divided by this ridge into two general watersheds, one draining toward the north and the other toward the south. About one-fourth the total area is estimated as mountainous, three-fifths as rolling plains, valleys, and arable slopes, the rest swamps. According to Humboldt, the general "face of the interior of the island is gently undulating, like that of England, and not more than 280 to 380 feet above the level of the sea." The rivers are numerous but short. Minerals are probably abundant, but of the metals, only copper, and, of late years, iron have been mined profitably. Coal of good quality abounds, and petroleum springs are found in some parts. Mineral springs of local celebrity exist in the different provinces. Those of San Diego, in Pinar del Rio, and at Madruga, the Saratoga of Cuba, southwest of Matanzas, are most frequented. The water of the latter contains iron, sulphur, magnesia, and potassa.

Flora.—The flora is tropical and abundant, and the soil is fertile. Extensive forests, so dense as to be almost impenetrable, exist. About 13,000,000 acres of uncleared forest yet remain. Mahogany, lignum vitæ, and other hard woods are plentiful. Coco-wood out of which reed instruments are made, and *Cedrela odorata* used for cigar boxes and linings of cabinet work, abound. Numerous varieties of palms, the most common and useful of the Cuban woods, are found. The fruits are those common to the tropics. Sugar-cane, tobacco, coffee, sweet potatoes, Indian corn, and rice are cultivated extensively. The first two are the staple products. Cattle raising is said to be profitable in the highlands.

Fauna.—Only a few mammals are known to be indigenous. None are large. Wild dogs and cats, sprung from the domestic animals, are numerous. Of the indigenous, the agouti, a rodent of the size of the domestic rabbit, is plentiful. The agouti is peculiar and common to all the West Indies. Another peculiar animal is an insectivore, the solenodon. Venomous reptiles there are none. There is a large snake of the boa variety called the maja, but it does not molest man. Crocodiles are found in the Isle of Pines, off the south coast. Insects are abundant in number and variety. Many arachnids are also found; but their bites, though painful, are said not to be dangerous. The rivers are well supplied with fish. Oysters and other shellfish are plentiful, but the quality is inferior. The peculiar marine mammal, the manatee, is found in the shallower waters along the coast. The birds are numerous, the parrot is the most conspicuous.

Climate.—The climate of Cuba has the general characteristics of all tropical islands: *i.e.*, high and equable temperature and humidity, and abundant rainfall. Its particular situation in the north tropical zone brings it within the region of the northeast trade winds. As elsewhere in the tropics, the year is divided into a hotter and wet season and a cooler and dry season, corresponding, north of the equator, with the northern and southern declinations of the sun. In all tropical regions, the heat and the rainfall are both greater the nearer the sun is to the vertical, or, in other words, they follow the sun. Local departures from these general characters are to be found, caused largely or entirely by differences in altitude, exposure and slope of the surface, and position with respect to the prevailing winds of the zone. From its geographical position and its configuration, Cuba undoubtedly presents many of these local variations. Unfortunately, however, the meteorological statistics available are too few and meagre to give other than a very imperfect idea of the local climates of the island.

Temperature.—Cuba lies between the sea-level isotherms of 77° and 80° F. The average temperature of Havana is 77° F. The highest temperature recorded at Havana is 100.6° F., and the lowest 49.6° F. At Guanabacoa on the coast, 5 miles east of Havana, the temperature for one year was 76.8° F., and at Matanzas, on the coast, 50 miles east of Havana, the mean temperature, two years' record, was 78° F., and the highest and lowest temperatures were 93° F. and 51° F. respectively. On the south coast, at Firmeza, 16 miles east of Santiago de Cuba, and 500 feet above sea level, the average temperature for ten years was 79.8° F. At Santiago the average temperature, determined from very incomplete records, is about 80° F. The highest temperature recorded in July, 1899, was 90.3° F., and the lowest in January of the same year was 67.5° F. At Cienfuegos the average temperature for eleven months was 76° F., and the highest and lowest were 94° and 49° F. respectively. A visitor to Trinidad de Cuba stated that during a winter spent there the temperature did not go above 84° F.

or below 64° F. in the interior. The mean temperature at Ubajay, a village about 15 miles southwest of Havana, and about 242 feet above sea level, from a series of four years' observations made in 1796–99, was 73.6° F. At the San Fernando mines, almost in the centre of Santa Clara province, at an elevation of 554 feet above sea level, the average temperature for one year was 75° F., and the highest and lowest temperatures were 98° and 51° F. The average temperature for eleven months at Puerto Principe was 75.6° F., and the highest and lowest temperatures were 98° and 49° F. respectively. The average temperature of the months of June, July, and August, and of December, January, and February, corresponding to the summer and winter seasons of north temperature latitudes, and respectively the warmest and coolest parts of the year in Cuba, differ about 10° F. at Havana and 6° F. at Firmeza. In the interior, the difference is greater than on the coast, and is probably from 12° to 18° F. Humboldt states that he was credibly assured that in the country near Havana, on a hill 318 feet above the sea level, water had frozen, the ice being several lines in thickness. Snow is said to have fallen once. The average temperatures (Fahr.) of the summer and winter months at several Cuban stations are shown in the subjoined table, together with the same data for several places in the West Indies and elsewhere:

Station.	Summer.*	Winter.†
Havana (ten years)	82.0°	71.2°
Ubajay (four years)	83.1	65.0
San Fernando mines (one year)	79.7	69.7
Firmeza (ten years)	81.4	75.9
Santiago (four years)	83.4	77.8
Key West, Fla. (twenty-one years)	83.8	71.1
San Juan, Porto Rico (twelve years	81.3	76.3
Kingston, Jamaica (ten years)	80.8	75.0
Praia, Cape Verde Islands (five years)	78.1	73.1
Honolulu, Hawaii (seven years)	77.2	70.6
Manila, Philippines (seventeen years)	81.3	77.3
New Orleans, La. (twenty-five years)	81.3	55.8
Galveston, Tex. (eighteen years)	83.3	55.6
Washington, D. C. (twenty-five years)	74.9	35.1

* June, July, and August. †December, January, and February.

San Juan, Kingston, Praia, Honolulu, and Manila are situated nearly within or not very distant from the same latitudes as the Cuban stations. The diurnal range of temperature varies a good deal in different months and in different localities. At Havana, the average is perhaps a little more than 10° F. The greatest daily range of temperature observed in five years was 23° F. The greatest daily range observed at the San Fernando mines in 1839 was 18° F. The maximum temperature of the day occurs generally between noon and two o'clock in the afternoon, and the minimum temperature usually between dawn and sunrise.

Humidity.—The average relative humidity at Havana is seventy-five per cent., and so little does it vary, that one month cannot be said to be drier or damper than another. The diurnal range is, however, considerable, varying from eighty-eight per cent. in the morning to sixty-four per cent. at noon. The absolute humidity averages from six to eight grains of vapor per cubic foot.

RAINFALL.—The fall of rain is, as a rule, greater during the months of May to October. On the average the greatest amount falls in October and the next greatest in June. Relatively the greater part of rain at Havana falls during the months from June to October, the average rainfall for which period is 32.37 inches, or sixty three per cent. of the annual fall. The average rainfall for the "dry season" is 19.36 inches. It is worth stating that four times in thirty years more rain fell in the "dry season" than in the "rainy season." The number of days in the year on which rain falls in Cuba is relatively large. At Havana, the average is one day out of every three. Notwithstanding the great frequency of rain, the days on which precipitation occurs are not continuously cloudy. As a rule, the rain falls in heavy showers, and the clouds generally break up as soon as the rain ceases, leaving the sky clear and bright. Out of 714 days on which rain occurred in the course of seven years, Ramon de la Sagra records that the rain fell after the middle of the day 449 times, before the middle of the day 146 times, and both before and after the middle of the day, 119 times. The divisions of the seasons of Cuba into "rainy" and "dry," as already alluded to, is purely a relative classification. More rain falls at Havana during the "dry season" than falls in the entire year at Denver, Col. (14.5 inches), or Los Angeles, Cal. (18.1 inches). The following table shows the average amount of rain falling in the "rainy" and "dry" seasons at several stations in Cuba and at a number of other places in the West Indies and elsewhere in the same seasons or in the corresponding time:

Station.	Rainy season, May to October.	Dry season, November to April.
	Inches.	Inches.
Havana* (thirty years)	32.37	19.36
Matanzas (one year)	44.01	11.28
Santiago (one year)	24.31	9.51
Firmeza (ten years)	47.78	13.97
Port au Prince, Hayti (four years)	39.05	22.12
San Juan, Porto Rico (twelve years)	35.83	25.38
Kingston, Jamaica (ten years)	26.03	6.61
Key West, Fla. (twenty-five years)	29.50	10.60
Honolulu, Hawaii (sixteen years)	14.65	24.89
Manila, Philippines (thirty-two years)	55.04	20.39
New Orleans, La. (twenty-five years)	27.00	33.52
Washington, D. C. (twenty-five years)	24.10	20.60

*Rainy season, June to October; dry, November to May.

Winds.—The prevailing winds are the "northeast trades." Except when influenced by the passage of cyclonic or anticyclonic areas, the wind blows steadily from points between east and north. During the passage of storms and areas of high barometric pressure, however, the winds may blow from any direction, being governed in this regard by the location of the centre of cyclonic or anticyclonic activity. In the winter season, cold waves in the United States, when extending far to the southward, cause cold northerly winds, or "northers" along the north Cuban coast. The average velocity of the wind at Havana is about 7.5 miles an hour. The diurnal variation in the velocity of the wind is much more pronounced than the seasonal variation. The wind increases with great regularity from a minimum of four miles per hour about 4 A.M., to a maximum of eleven miles per hour at 2 P.M., and then declines gradually to its minimum. In a climate having such high temperatures and humidities as that of Cuba, the velocity of the wind and its constancy are of the greatest importance to comfort and health.

Storms.—Thunder storms, accompanied by profuse electrical display, are of frequent occurrence; especially is this so during the summer, when they are almost a daily characteristic of the afternoon weather. Very little damage, however, results from either the wind or the lightning. Cuba, in common with the other islands of the West Indies, is occasionally visited by very destructive storms of the class known as tropical hurricanes. Fortunately these storms are of infrequent occurrence, and when they do happen, their destructive energy is limited to a relatively narrow region in the course of their path. Experience and statistics both show that these storms are most likely to occur in August, September, and October. The history of 22 of these hurricances occurring since 1872 has been collected and their paths have been determined; of the 22 only 7 passed over Cuba. The following table shows the average climatic conditions for ten years at Havana.

HEALTH.—Cuba has a somewhat unenviable hygienic reputation. Climatically, there is no reason why Cuba should not be as healthful as Jamaica or Porto Rico. The prevalent diseases are fevers of the malarial type, yellow fever, dysenteric disorders, and tuberculosis. The mortality is high. From the best sources Chaille esti-

Havana.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Temperature (degrees, Fahrenheit)—													
Mean	70.3	72.0	73.2	76.1	78.8	81.5	82.4	82.2	80.7	78.1	75.3	71.4	76.8
Highest	84.4	87.6	91.4	93.6	99.0	97.7	100.6	98.6	96.6	91.9	88.7	86.0	100.6
Lowest	52.2	49.6	55.0	52.9	64.4	69.1	71.2	69.8	70.9	61.7	56.5	51.8	49.6
Rainfall—													
Mean	2.32	2.52	2.50	1.46	5.15	8.29	5.09	5.43	7.62	8.49	4.24	1.93	55.14
Greatest	6.31	6.18	5.05	5.67	17.51	17.56	7.13	9.36	13.57	13.53	7.94	5.56	60.06
Least	.02	.20	.56	0.00	.33	1.50	3.10	1.45	3.15	1.47	1.45	.30	46.0[illegible]
Number of days on which rain fell -													
Mean	7.5	6.2	5.9	3.8	9.9	14.3	13.0	13.3	16.7	15.6	12.3	9.0	127.5
Greatest	14	11	10	9	16	20	16	21	25	22	18	16	149
Least	1	2	3	0.00	3	7	11	9	11	10	8	4	120
Humidity—													
Mean relative per cent	75	73	70	69	71	76	74	75	79	78	77	74	74
Mean absolute grains per cubic foot	6.2	6.4	6.3	6.8	7.6	8.7	8.8	8.8	8.9	8.1	7.4	6.3	7.5
Wind—													
Average velocity, miles per hour	7.8	8.3	8.7	9.2	7.8	6.7	6.5	6.3	6.5	7.8	8.7	8.3	7.8
Prevailing direction	E.	E.	E.	E.	E.	E.	E.	E.	E.	N. E.	E.	E.	E.

mated the death rate of Havana as 36.3 per 1,000, of Guanabacoa as 39.8 per 1,000, and of Marianao as 39.5 per 1,000. These latter places are suburban resorts of Havana, much frequented by invalids; hence the probable cause of their increased mortality. Among the diseases causing death, the Havana statistics show tuberculosis first, intestinal diseases second, and fevers third. Yellow fever is endemic in Havana and most of the other sea ports. It is infrequent in the interior of the island, and always the result of importation. The sanitary conditions of Havana and the other larger cities and towns are bad. A special report shows that three-fourths of Havana's population live in the most densely populated locality in the world. Crowded together in badly ventilated dwellings, with floors directly on the soil, and sinks and cesspools at the doors, with no sewage system, it is not to be wondered that disease finds congenial aboard. With intelligent sanitation, Havana (and Cuba) can be made as healthful as any other place in the tropics.

Precautions for Visitors.—No water should be drunk, unless previously filtered or boiled. Food should be well and properly cooked, and should be partaken of moderately. As a rule, persons going from a colder to a warmer climate experience some loss of desire for food; this is natural, and should occasion no uneasiness. No effort should be made to get up an appetite by the use of stimulants. Linen or cotton garments should be preferred to woollen. Clothing should be worn loosely about the body, especially about the abdomen and the throat. Wet clothing should be exchanged for dry as soon as practicable. At night it is a wise precaution to protect the abdomen by using a bandage of gauze or other light material, as it lessens the likelihood of undue cooling from nocturnal radiation which is relatively very great in tropical latitudes. For the same reason the night should be passed under roof, or shelter of some kind. A mosquito net should always be used as a protection from mosquitoes, gnats, and other biting insects, all of which may carry disease germs and infect by their bites. Exercise and work should be engaged in moderately at first, and then only during the cooler parts of the day, that is, before 10 A.M. and after 3 P.M., and never at night. An umbrella should be used as much as practicable when one is exposed to the sun. *W. F. R. Phillips.*

CUBEB.—Cubeba. "Cubebs." "The unripe fruit of *Piper Cubeba* L. (fam. *Piperaceæ*)" (U. S. P.).

This species is a climbing plant with perennial, smooth, flexuous, branched stems, and alternate lanceolate, bright green, and shining leaves. The flowers are diœcious and aggregated in close linear catkin-like spikes. Native of Java, Sumatra, Borneo; also cultivated in the coffee plantations of Java and Sumatra, as well as in the West Indies. The drug generally reaches us through the commercial ports of India. It has been known in Europe since the Middle Ages, having been introduced through the Arabian physicians, and its earliest employment appears to have been as a spice. It was, however, used in genito-urinary troubles by the Arabians centuries ago; but that employment either never took any hold in European medical practice or completely died out long ago, and was not revived until the beginning of the present century, when it was reintroduced by medical officers stationed in India.

"Cubeb" consists of the whole fruits dried. They are about 5 mm. ($\frac{1}{5}$ in.) in diameter, globular, wrinkled by the shrinking of the juicy mesocarp, slightly pointed at the apex, sometimes flattened at the base, from which the slender brittle stalks, in reality the narrowed portion of the fruit, projects from 2 to 6 mm. They each contain a roundish stone within which is a single flattish seed, or, as the fruits are collected before maturity, frequently an air space. Color, grayish-brown, or blackish; odor, strongly aromatic and peculiar; taste, spicy, but milder than that of pepper.

Cubeb has been the subject of very extensive adulteration, and the adulterants have been numerous, chiefly the fruits of other species of Piper. They are to be distinguished chiefly by the characters of the stalk and the taste. The stem (rachis) of the cluster, which is to be sifted out, is also extensively sold for cubeb, in the ground state.

Cubeb contains from six to twelve or more per cent. of a composite *essential oil,* which is official (*Oleum Cubebæ*, U. S. P.), also about three per cent. of an amorphous resin, nearly an equal amount of *cubebic acid,* and *cubebin*, besides some fat and other uninteresting ingredients. Cubebin is bitter, but nearly inert. The resin and cubebic acid are active, but the value of the drug depends chiefly upon the oil, which is considered below. All the above substances combined, extracted by ether and concentrated by evaporating the solvent, compose the so-called "Oleo-resin of Cubeb" (*Oleo-resina Cubebæ*, U. S. P.), of which the yield is from sixteen to twenty per cent. of the cubeb.

Action and Use.—Cubeb is mainly an aromatic spice, like its near relative, pepper. The odor and flavor are due to its oil, the pungent taste to its amorphous resin. As a local stimulant to digestion, as an ingredient of cough mixtures and gargles, it has a certain value which it shares with others of its class. But nearly all the call for cubeb is in diseases of the bladder and urethra, especially in gonorrhœa and gleet. It is eliminated by the kidneys, whose secretion it augments slightly and scents decidedly, and the urine so impregnated soothes the bladder and urethra, through which it passes, and diminishes the formation of pus—by exactly what process cannot be said.

The drug is distinctly inferior to copaiba, for the same purpose.

Its irritating effect upon the stomach is apt to be reflected upon the skin by an erythematous eruption, which, however, cannot be regarded as characteristic of this drug.

ADMINISTRATION.—It may be given in powder, the dose of which is from 4 to 10 gm. (2 to 4 gm. = ʒ ss. to i.); the bulk is generally an objection. There are official, besides the oleo-resin, a fluid extract and a twenty-per-cent. tincture, both good, which may be reduced, if desired, by syrup or mucilage. The oleo-resin represents about six times its weight of cubeb. From the oleo-resin are made the troches of cubeb, each containing 0.04 gm. (about gr. ss.), considerably used as a popular "expectorant" in pharyngitis, etc. *Henry H. Rusby.*

CUBEB, OIL OF.—OLEUM CUBEBÆ. The source of this oil is explained above. It varies from colorless to greenish or yellowish, has a specific gravity of about 0.920 and dissolves in an equal volume of alcohol. It has the characteristic odor of cubeb. It consists chiefly of cadinene ($C_{15}H_{24}$), apparently identical with the active portion of oil of copaiba. Upon keeping the oil, a portion of it becomes converted into cubeb camphor ($C_{15}H_{24}.H_2O$). The same change occurs in it in the fruit if the latter becomes old, and this product will be contained in the oil distilled from such fruit. Oil of cubeb has the same properties as cubeb, and is given for the same purposes, in doses of 0.3 to 1 c.c. (♏v. to xv.). *Henry H. Rusby.*

CUCUMBER. See *Cucurbitaceæ.*

CUCURBITACEÆ.—(The Cucumber or Gourd Family.) A family of some ninety genera and more than five hundred species, of great economic interest, both generally and medicinally. The plants are perennial, tendril-bearing herbs or undershrubs, rarely shrubs, and either prostrate or climbing. They inhabit warm, and especially tropical regions, throughout the globe. They are of rather delicate vitality and easily destroyed by accident, yet they are very commonly inhabitants of sandy, arid regions, and the family is noted for its protective provisions. Most common among these are purgative or poisonous constituents. These are very commonly stored in large fleshy and starchy roots, like the bryony, many of which have to endure long periods of rest, subject to decay, against which they can be protected by resins, and to attacks by foraging animals, against which they are protected by poisonous glucosides. The pulpy fruits, like those of colocynth and elaterium, are often similarly protected. The seeds are very commonly anthelmintic and diuretic. Besides the well-known drugs colocynth, elaterium, bryony, and pumpkin seed, separately considered, a very large number are used locally, or in domestic practice, for the same purposes. Among such seeds may be mentioned those of squash, cucumber, and melon; among roots, various species of Wilbrandia, Megarhiza, Cayaponia, Corollocarpus, Kedrostis, Modecca, Melothria, and Lagenaria; among fruits, species of Luffa, Momordica, and Trichosanthus, besides those of some of the above-mentioned genera. The use of the bland pulps of some of these fruits, such as cucumber, for poultices, is to be regarded as chiefly, if not wholly, mechanical. The juice of the stems and fruits frequently carries the drastic principle. Upon the other hand, many of our most useful vegetables are derived from these fruits, as the melons, pumpkins, squashes, cucumbers, citron melons, cayotes, calabashes, and acchocte. The well-known dish-rag gourd is elsewhere considered. *Henry H. Rusby.*

CUDBEAR. See *Litmus.*

CUINCHO.—Michoacan, Mexico. These springs are located 10 kgm. northwest of the city of Morelia. The water has a temperature of 100° F. Dr. Zuñiga, to whom we are indebted for a study of these springs, says, in speaking of the water: "It is perfectly clear, odorless, colorless, its taste is insipid and its reaction neutral." It contains eighteen grains of fixed substances per United States gallon and on analysis yields the following results: Lime, magnesia, soda, chlorine, and carbonic acid. A recent issue of the Mexican Pharmacopœia says the water contains sulphate of lime and magnesia, carbonate of lime, carbonate of potassa, and carbonate of soda and magnesia, with some chloride of lime and magnesia.

Notwithstanding the fact that the bathing facilities are rather primitive in character, large numbers of people employ these waters in the belief that they are useful in such affections as chronic malaria, hypochondriasis, and the uric-acid diathesis. *N. J. Ponce de Léon.*

CUMARIN, or COUMARIN.—*Cumaric Anhydride. Tonka Bean Camphor* ($C_6H_4.O.CO.CH.CH$). This is the odorous principle of a number of plants or plant parts, more especially of the tonka bean, the deer's-tongue, sweet clover or melilot, and a number of species of grasses, notably the *Anthoxanthum odoratum* L. and *Savastana odorata* (L.) Scribn. It is also largely produced artificially in several ways. It occurs in white crystals which melt at 67° C., and which are soluble in alcohol but not in water. In all of these plants it can scarcely be detected in the fresh or growing state, but develops in drying. In the tonka bean it is developed by the action of alcohol, which frequently leaves the beans with a crystalline surface, due to this substance. This is frequently rubbed off, wholly or partly, and even replaced by similarly appearing substances. Cumarin has an odor very similar to that of vanilla, and a burning taste. It is exclusively employed for perfuming and flavoring, chiefly to substitute vanilla. Large doses are said to exert a primary stimulant and a secondary paralyzant action upon the heart. *Henry H. Rusby.*

CUMIN.—CUMMIN. CUMINUM. The fruit of *Cuminum Cyminum* L. (fam. *Umbelliferæ*), a low annual of the caraway type, probably of Asiatic origin, but extensively cultivated in China, India, and parts of Europe for its aromatic fruits. The odor and taste are strongly aromatic, but less pleasant than many others in the family, on which account it is scarcely used in this country.

Cumin yields about three per cent. of a clear, yellow *essential oil* of spicy taste and odor, and having the general medical properties of the innocuous portion of the family. The oil is separable into *cuminol* or cuminaldehyde ($C_{10}H_{12}O$) and *cymol* ($C_{10}H_{14}$). Cumin is used everywhere in the East, and to a less extent in Europe, as a domestic flavor, and is said to be one of the components of curry powder; also an ingredient in some European liqueurs. In plasters and liniments, and in veterinary practice, it is also occasionally employed. It is an excellent carminative. The dose is 0.5 to 2 gm. (gr. viij. to xxx.); of the oil, ♏ ij. to viij. *W. P. Bolles.*

CUPREA BARK. See *Cinchona.*

CUPRIASEPTOL.—$Cu(C_6H_4.OH.SO_3)_2.H_2O$. Copper phenolsulfonate, copper sulphocarbolate. This is prepared by heating a mixture of phenol and sulphuric acid, and saturating the product with copper oxide. It occurs either as small light-green needles or as a coarse crystalline powder, and contains 12.4 per cent. of copper. It is recommended as a hæmostatic. *W. A. Bastedo.*

CURARE.—*Woorari. Ourari.* This is a complex mixture of inspissated juices, which, in the relatively fresh state, is used as an arrow poison by the Indians of South America. Its composition is not known, but investigations have shown that there is always present the juice of certain species of *strychnos* which are indigenous to the country. Other species of strychnos are the source of similar poisons. In Java and Borneo, *S. tiente* yields a poison also used by the natives for poisoning their arrows; in Africa, *S. incaga* Baill. and *S. kipapa* Gigl. are the source of a powerful ordeal poison; and many other species supply active poisons, among them the well-known *S. nux vomica* L. The composition of curare varies according to the tribe from which it is obtained, each tribe selecting the tree growing in its immediate neighborhood and preparing the juice according to its tribal custom. Four varieties have been described:

First, that of the Amazon valley, from *S. Castelnæana* Weddell, a large woody climber growing in most parts of Brazil, and also in Colombia and among the Andes. The bark of the stem is the part employed. Secondly, that of the upper Orinoco region, from an imperfectly known species *S. gubleri*, possibly identical with *S. toxifera* Bentham. Thirdly, the curare of British Guiana which is attributed to the just-named *S. toxifera.* And, finally, that of French Guiana, which, on the authority of Dr. Crévaux, is attributed to *S. Crévauxii* Baillon.

The method of preparation has been described by travellers, some of whom spoke only from hearsay, while others were present during its compounding. The bark of the vine is the part employed. It is scraped and cut into small pieces, and the juice is obtained by a crude method of percolation and infusion. To this product are added the juices of several other plants, and, in some specimens, ants are found incorporated, and it is also said that the venom of certain snakes is added. Our knowledge of the manufacture and composition of curare is very obscure, and we are not able to distinguish the various forms that reach the market. It comes in earthenware pots, or in vessels formed from gourds, into which it has been poured when in a liquid state.

It occurs as a dark, brittle extract, with a disagreeable odor and a bitter taste. It is almost entirely soluble in water.

The active principle *curarine,* discovered in 1856 by Preyer, is separated as a colorless crystalline body, very deliquescent, very bitter in taste, and alkaline in reaction. With sulphuric acid it gives a blue color which serves to distinguish it from strychnine.

Curare exercises a depressant action upon the peripheral terminations of the motor nerves, affecting first the voluntary and later the involuntary muscles. When it is administered in small doses the brain and sensory nerves remain unaffected, but when it is given in large doses its effects extend to the central nervous system, producing a general paralysis, with disturbed special senses and loss of consciousness. Death takes place from failure of respiration, the respiratory muscles being affected earlier than the respiratory centre. Curare is rapidly absorbed and as rapidly removed from the system with the urine. In many cases of poisoning, this excretion of the poison favors the adoption of artificial respiration as a very rational mode of treatment. The kidneys begin to act quickly, and the poison may be eliminated in a few hours. If respiration can be maintained for that period the effects of the poison may be readily overcome. During the action of curare the body temperature is raised. After moderate doses there is a gradual failure of muscular power with loss of reflexes, and this may terminate in complete motor paralysis. The respirations are more frequent and become shallow and labored. The pulse is increased in force and frequency. The secretion of urine becomes greater. When the drug is given in larger doses all these symptoms are aggravated. There is also some fever, with marked depression. The heart becomes feeble and the vessels are dilated; and shivering alternates with fever, trembling, and clammy perspiration. According to reports, some specimens of curare produce muscular twitching and spasms.

As a therapeutic agent curare is of little value. Its power of preventing muscular contractions has suggested its employment in all conditions in which muscular spasm is a prominent symptom. In these, however, it cannot prove of much value, as it produces its effect through the peripheral nerves, and has little or no action upon the central nervous system, such as calabar bean and similar drugs exercise. It has been employed in poisoning with strychnine, and in hydrophobia, tetanus, epilepsy, and chorea. A case of hydrophobia has been reported in which the spasms were controlled by curare in doses of from gr. $\frac{1}{8}$ to $\frac{1}{2}$, administered hypodermically, and recovery ensued. In a case of tetanus, gr. iv. were administered during twenty-four hours with success.

The dose of curare is from gr. $\frac{1}{10}$ to $\frac{1}{2}$, to be administered hypodermically. Its effects require to be carefully watched, the smallest dose being given at first, and the amount being gradually increased until the desired effect is procured. When a new supply of the drug is obtained, the same care in determining the dose is to be observed. On account of the great unreliability of the drug, it has been advised that *curarine* should be employed, the dose of which, to begin with, is gr. $\frac{1}{400}$.

The rapid action of curare, when injected beneath the skin or when applied to the denuded surface, is not evident when it is administered by the stomach or bowel. This slow absorption by mucous surfaces has given rise to the idea that it has no effect when given in this way. When it is administered in larger quantities its action is equally severe. Its diminished activity is explained by the rapid elimination of the poison, which is removed almost as quickly as it is absorbed. Another explanation is that the poison is neutralized as it passes through the liver by way of the portal vein. *Beaumont Small.*

CURCAS. See *Jatrophaie.*

CURCUMA.—TURMERIC. The rhizome of *Curcuma longa* L. (fam., *Zingiberaceæ*), a perennial, flag-like herb of India, where, as well as in other parts of Asia, it has long been cultivated.

Curcuma is distinguished in trade as "long" and "round" varieties, which for a long while were supposed to be from different plants. They are now known to be the principal and lateral rhizomes of the same. Round curcuma is about as large as a pigeon's egg, oval, flattened, rounded at the ends and encircled by the lines of numerous nodes. The long variety, which is more common, is from 3 to 6 cm. long, and from 0.5 to 1 cm. in diameter (2 in. × $\frac{1}{8}$ in.), encircled by a number of distinctly marked nodular rings. The different varieties range in color, externally, from bright yellow (Madras) to brown (Bengal) or gray (Java); internally from deep yellow through orange and brown to nearly black. Odor strong, peculiar, not disagreeable; taste aromatic, bitterish. It contains a clear yellow *essential oil,* which is its aromatic portion, much fixed oil, resin, and a deep yellow, crystalline coloring matter, *curcumin,* which becomes carmine red with acids, and reddish-brown with alkalies.

Properties similar to those of ginger, but not much used here—either as a medicine or as a condiment. It is extensively consumed in Asia as a spice, and is the basis of curry. In the arts, tumeric is employed to dye cloths yellow; in chemistry, to a slight extent, as a test for alkalies; in pharmacy, now and then to color ointments and other preparations. It is largely employed as an addition to ground mustard, to ameliorate its acridity, genrally regarded as too great to admit of the table use of the pure article, and also as an adulterant of the same in its medicinal form. *Henry H. Rusby.*

CUTTLEFISH BONE.—A very light and fragile calcareous skeleton found in the cuttlefish, *Sepia officinalis* L. (order, *Dibranchiata, Loliginea*). The "bone" of this Mediterranean mollusk is found in the dorsal part of the body beneath the mantle. It is obtained by collecting the mollusks and allowing them to putrefy, or by picking up those that wash ashore. When whole it is of oblong or lanceolate outline, strongly flattened, with one surface (the dorsal) hard and smooth, and one very spongy, light, and friable. The structure is very open, laminated, and light, the entire bone when dry floating upon water. Odor, none or slight; taste, saline.

There is a considerable demand for cuttle bones—partly for cage-birds and partly for dentifrices, polishing powders, face powders, etc. It consists almost entirely of carbonate of lime, with a little phosphate of lime and some animal matter. Its early use as an antacid, etc., is now of the past. *W. P. Bolles.*

CYANIDES.—The only cyanides that concern the physician are those, respectively, of *silver, mercury,* and *potas-*

sium. Silver cyanide is a white insoluble powder, official in the United States Pharmacopœia, but solely for pharmaceutical use, the salt being a possible source for obtaining, extemporaneously, diluted hydrocyanic acid (see *Hydrocyanic Acid*). Mercuric cyanide is a soluble salt which will be found discussed in the article *Mercury*, and concerning which it is only necessary to remark in this place, that the salt adds to the irritant properties of the mercuric salts generally, a peculiar virulence due to the acid radicle of its composition. Potassium cyanide is a soluble, and therefore physiologically active, salt, wherein the comparatively mild properties of the basic radicle are entirely overshadowed by the intensely poisonous potency of the acid element; for hydrocyanic acid in combination with the bases of the alkalies proves itself exactly as poisonous as in its free state, so that the alkaline cyanides, in proportion to their weight in acid radicle, are the medicinal or toxic equivalents of the uncombined acid. Potassium cyanide, being therefore practically but a carrier of hydrocyanic acid, is considered under the present heading rather than among the salts of potassium generally.

Potassium Cyanide, KCN.—Potassium cyanide is official in the United States Pharmacopœia under the title *Potassii Cyanidum*, Potassium Cyanide. It occurs in "white, opaque, amorphous pieces, or a white, granular powder, odorless when perfectly dry, but in moist air exhaling the odor of hydrocyanic acid. The taste is sharp and somewhat alkaline, but should be ascertained with great care, as *the salt is very poisonous*. In moist air the salt deliquesces. Soluble in about 2 parts of water at 15° C. (59° F.). Boiling water dissolves its own weight of the salt, but rapidly decomposes it. In alcohol it is but sparingly soluble. At a low red heat the salt fuses" (U. S. P.). It should be kept in well-stoppered bottles, since it tends to a slow decomposition by exposure. Potassium cyanide represents, in sixty-five parts, thirty-nine parts of basic and twenty-six of acid radicle; and so, according to what has been said above concerning the alkaline cyanides generally, about two and a half parts of this salt represent, physiologically, the virtues of one part of anhydrous hydrocyanic acid. The salt in concentrated application is very painful to raw and sensitive parts, and taken internally acts precisely after the manner of hydrocyanic acid (see *Hydrocyanic Acid*), except that it is rather slower of operation. A dose anywhere between 0.20 and 0.30 gm. (gr. iij. to v.) is ordinarily fatal, and death commonly results in from fifteen minutes to two hours. Poisoning can arise also from absorption, externally, through abrasions, and even the inhalation, in a close chamber like a photographer's "dark closet," of the fumes arising from an exposed strong solution may excite symptoms. In case of poisoning by the internal taking of the salt, Taylor (on Poisons) advocates the giving of ferrous sulphate as a special antidote, because of the reaction between the two salts whereby the insoluble and innocent substance *Prussian blue* is formed. The same author cites the case of a photographer who, upon accidentally swallowing a solution of potassium cyanide, immediately drank of a photographic "developing" solution containing ferrous sulphate, vomited Prussian blue, and survived.

Medicinally, potassium cyanide is a possible substitute for hydrocyanic acid, proposed because of greater stability. Internally, it may be given in doses of from 0.005 to 0.008 gm. (from gr. $\frac{1}{12}$ to $\frac{1}{8}$), in water or syrup. Many prescribe it in conjunction with vinegar or lemonade, with the view of setting free hydrocyanic acid from the salt, but the procedure is not necessary. Externally, an aqueous solution ranging from one-fifth to one per cent. in strength is occasionally prescribed as a lotion for the relief of surface pains or itching. A special use of potassium cyanide is to remove stains of silver nitrate from the skin, provided such stains be recent and not yet exposed to strong sunlight. A solution, or a moistened lump of the salt, is rubbed upon the blackened skin, and the part afterward well washed in water. Due regard must be paid to the very poisonous nature of the cyanide, and especially, application of the salt to cut or excoriated parts should carefully be avoided.

Edward Curtis.

CYCLAMEN.—The tuber of *Cyclamen Europæum* L. (fam. *Primulaceæ*), a plant largely cultivated in the house for ornament. It contains the glucoside *cyclamin* ($C_{20}H_{34}O_{10}$), occurring as a white powder, and yielding *cyclamaretin* on decomposition. It is soluble in alcohol and forms a frothy solution with water. It is in other respects very similar to saponin, quickly developing an exceedingly burning and acrid taste, and very highly irritant to mucous membranes. It can be absorbed by rubbing upon the sound skin, and produces thus its characteristic effects. It is an irritant-purgative, emetic in over-doses, and may act as a fatal drastic poison. Its use in domestic practice is as a purgative and anthelmintic, the powdered form being given in doses of 1 to 3 gm. (gr. xv. to xlv.). *Henry H. Rusby.*

CYLINDROMA. See *Endothelioma.*

CYPRESS.—*Cupressus* L. A genus (fam. *Coniferæ*) of a dozen species of temperate or subtropical regions of the northern hemisphere. The composition and properties are in general those of juniper, savin, arbor vitæ, and others of the family.

Cypress oil is distilled from the fresh leafy twigs of *C. sempervirens* L., the Oriental cypress of southern Asia. The evidence is conclusive that the inhalation of this oil gives marked relief from the paroxysms of whooping-cough, and favors recovery. The only method recommended for its employment is to scatter a few drops upon the pillow, or to spray it about the room, but it would appear that a suitable solution for use in the inhaler might easily be devised. *Henry H. Rusby.*

CYPRIPEDIUM.—Ladies' Slipper. Moccasin Flower. *American Valerian. Nervine.* The rhizome and roots of *Cypripedium hirsutum* Mill. ["*C. pubescens* Swz.," U. S. P.], and of *C. parviflorum* Salisb. (fam. *Orchidaceæ*). These plants are perennial herbs, arising from a horizontal rhizome by a pubescent, leafy, few-flowered stem half a metre or more in height. Leaves also pubescent, broadly oval, acute, parallel-nerved; flowers one to three, the most conspicuous part of which is the large inflated, pouch-like lip, in the former, one and a half to two inches long, in the latter about half as large, from which it and others in the genus derive their name. Rather common in moist woods, the latter more abundant in the Northwest.

The rhizome, with its adhering roots, is collected. It is "horizontal, bent, 4 in. (10 cm.) or less long, about $\frac{1}{8}$ in. (3 mm.) thick; on the upper side beset with numerous circular, cup-shaped scars; closely covered below with simple, wiry roots, varying from 4 to 20 in. in length (10 to 50 cm.); brittle, dark brown or orange-brown; fracture short, white; odor faint, but heavy; taste sweetish, bitter, and somewhat pungent."

It contains a *volatile oil*, a *volatile acid*, *tannic* and *gallic acids*, *resins*, *gum*, *starch*, etc. These constituents make cypripedium a gently stimulant and mild antispasmodic, of the hop and valerian kind. The dose is 0.5 to 2 gm. (gr. viij. to xxx.), and it is best administered in the form of the official fluid extract, or sometimes still better in the form of a twenty-per-cent. tincture.

Henry H. Rusby.

CYRTOMETER.—(*κύρτος*, curve; *μετρον*, measure.) The cyrtometer is an instrument which can be so adapted to a given part of the body as to reproduce its curves and inequalities. The word is sometimes, though less correctly, applied to callipers, an instrument used in measuring the diameter or thickness of a body. Under the name of "Wilson's cyrtometer" an instrument has been described for ascertaining the position, length, and direction of the fissure of Sylvius in the living subject; for cuts and a full description of the device, the reader is referred to the original article on "Cranial Surgery," by Dr. A. W. Hare in the *Lancet*, March 3d, 1888.

The cyrtometer was first described by Andry and Bouillard in 1810, but was not extensively used until 1857, when Woillez, in a paper entitled "Recherches Cliniques sur l'Emploi d'un Nouveau Procédé de Mensuration dans la Pleurésie," described an instrument consisting of two halves of a jointed whalebone, connected by a hinge and capable of being accurately adapted to the shape of the chest. The cyrtometer of Fourmantain was a still later device composed of a circular spring which was applied to the thorax and adjusted by means of a clasp, while the curve was reproduced on paper on the principle of the pantograph.

All the instruments which have been mentioned were unnecessarily complicated, and time and custom have so simplified them that the modern device is easily obtained and is very practical. It consists of two strips of lead, each about one-half inch in width, one-tenth inch in thickness, and from eighteen to twenty inches in length. Such a piece of lead is so malleable that it may easily be moulded to any desired shape by simple manual manipulation, and at the same time it is of sufficient consistency to retain its form if handled with ordinary care, and it may also be straightened and freed from curves by striking vigorously its flat surface once or twice against a hard floor.

The cyrtometer is principally used for determining the character and degree of deformity that have been produced in the chest or abdomen as a result of certain pathological processes such as may occur in pleural exudations, lateral curvatures of the spine, kyphosis and lordosis, rhachitis, etc., or in tumors of the abdomen. It is also useful in tracing in infants the configuration of the head which has been altered as a result of abnormal labor, rhachitis, or hydrocephalus. In short, it is useful whenever it is desired to show the result of any cause so acting as to alter the symmetry of the lateral halves of the body.

If, for instance, it is desired to reproduce the shape of a distorted thorax, one starts by marking on the body anterior and posterior points which shall lie in the antero-posterior median plane of the body and on the same horizontal level. The strips of lead are then moulded by manual manipulation so as to conform to each half of the chest, their anterior ends meeting at the anterior median point, their posterior ends overlapping at the posterior median point, or being so bent that their angles will meet at this posterior point. Each strip is then removed, and the two halves are again adjusted to each other by placing them upon a piece of paper resting upon a flat surface. The inner circumference of the two halves is then traced by pencil upon the paper, the anterior and posterior meeting points are marked, and they are connected by a straight line which will correspond to the median plane of the body. The degree of asymmetry of the lateral halves will then be apparent, and, if desired, the curves may be reproduced upon any desired scale by the use of the pantograph. If, in cases in which there is a lateral deviation of the spine, there be noted, by suitable nicks on the lead strips, not only the anterior and posterior median points, but also the position of the spine of the vertebra and the median point of the sternum at the same level, their positions may be recorded upon the tracing, and the line connecting them will show the relation of the spine and mid-sternum to the antero-posterior plane.

On the same principle one may take tracings of any other part of the body and thus give a more graphic representation of the contour of a deformed part than can be obtained by simple mensuration. *Maynard Ladd.*

CYSTADENOMA.—(Cystoma, Adenocystoma.) The dilatation of the glandular spaces of an adenoma through the excessive formation of secretion gives rise to a cystic tumor which from its origin is best designated by the term cystadenoma. The growths belonging to this class are distinguished from the cysts in that in the former the cystic change is always preceded by a new formation of gland tissue which later becomes converted into cysts by the accumulation of secretions and the subsequent proliferation of the walls of the gland spaces. There is consequently in the cystadenoma a progressive formation of cysts out of newly formed glandular tissue, and to this process there is no definite limit of growth. In the true cysts such new growth of gland tissue does not occur, and there is not a continuous formation of new cysts. The difference between a cyst and a cystadenoma is essentially that existing between a gland and an adenoma. Nevertheless, it is at times very difficult to draw sharp lines of distinction between the cyst and the cystadenoma. This is especially the case in regard to the proliferation cysts, since from these the cystadenomata frequently take their origin. The differential diagnosis will rest ultimately upon the establishment of the facts concerning the formation of new gland tissue preceding the cyst development.

The earliest stages of the formation of a cystadenoma are seen in the gradual dilatation of some of the spaces of an adenoma through the over-production of secretions. As soon as the dilatation of the gland space has reached such a point as to become visible to the naked eye on cross-section of the growth, it may be said to be cystic. With a preponderance of such cyst formation the adenoma gradually becomes changed into a cystadenoma. In its first stages of development the cystadenoma consists of numerous small cysts lying in a more or less well-developed connective-tissue stroma. The growth of some of the cysts may be more rapid than that of others, leading to the formation of a tumor containing both large and small cysts, often in such a manner that it may consist of a few large cysts bearing in their walls numerous smaller ones. The cystic change may not involve all of the glandular tissue of the adenoma, so that in or near large cysts there may be found gland tissue which contains only small cysts or appears solid. Not infrequently the gland spaces of an adenoma become cystic as soon as formed, so that the growth bears the character of a cystadenoma from the beginning without passing through a definite intermediate stage of adenoma.

Since the cystadenoma arises from numerous gland spaces it consists of many chambers (multilocular cystoma). Only through the atrophy of the intervening walls does the true cystadenoma become monolocular. The cyst spaces may be separated from each other by a very narrow wall of connective tissue, or by one so thick that they lie at some distance from each other. In the latter case the formation of connective tissue may so preponderate over that of the cysts as to justify the use of the term cystadenofibroma or cystofibroma. If the connective tissue becomes myxomatous in character, as is not infrequently the case, the growth may be styled cystadenomyxoma or cystomyxoma. Occasionally the connective tissue undergoes a rapid proliferation and takes on an embryonic character. The term cystosarcoma has been applied to such tumors, but their manner of growth does not justify their classification as sarcomata. They do not form metastases, and their growth is wholly by expansion. Hyaline change and calcification are not infrequently found in the stroma of cystadenomata, the latter often occurring in the shape of psammoma-like concretions.

The lining of the cysts is simple columnar epithelium in the great majority of cases, occasionally ciliated, and less frequently cubical or flattened. The inner surface of the wall may be smooth (cystoma simplex), or the connective tissue of the wall may extend out into the cavity of the cyst as little papillæ covered with epithelium (cystoma papilliferum or proliferum). These papillæ may be delicate, simple, blunt, or pointed, or they may be dendritically branched (polypoid cystadenoma). If the growth of connective tissue in the papillæ is so extensive as partially or wholly to fill up the cyst cavity, the tumor may be designated intracanalicular cystofibroma. Retrograde changes not infrequently occur in the lining epithelium: mucous, fatty, or colloid-like degenerations, necrosis, desquamation, calcification, etc. Inflammation of the cyst walls may occur as in the true cysts, but is of much less frequent occurrence.

The content of the cysts is usually a clear, slightly stringy or glairy fluid like white of egg, containing mucin, pseudomucin, albumin, albumose, the so-called paralbumin, etc. All of these are the products of the lining epithelium. White or yellowish masses of cells showing fatty degeneration or necrosis may be contained in the fluid. The entire lining epithelium may be converted into goblet cells, and the latter may also be found free in the fluid of the cyst cavity. In the case of inflammation of the wall or secondary infection of the cyst contents the latter, through the addition of inflammatory exudates, become fibrinous, purulent, or gangrenous. In the latter case gas, sometimes of an inflammable nature, may be formed in the cysts. Hemorrhages may also occur into the cyst spaces. As a result of these the contents of the cysts may contain broken-down red blood cells and blood pigment, acquiring from their presence a brown or reddish-brown color. Cholesterin, fatty-acid crystals, concretions of lime salts, corpora amylacea, colloid-like bodies, etc., are not infrequently found in the cyst contents.

Cystadenomata may arise from:

1. Normal glands, most frequently from the ovaries, testis, mammary glands, uterus, liver, and kidneys.
2. Adenomata of any gland, especially from those of the ovary, mammary glands, uterus, testis, liver, and kidneys.
3. From fœtal gland structures in normal or abnormal locations, from teratomata, etc.

Between the cystadenoma simplex and the papillary form no sharp line can be drawn, as papillary proliferations are frequently found in the walls of simple dilatation cysts. The two forms usually exist together in combination (cystadenoma partim simplex partim papilliferum). The papillæ may be delicate and narrow, or they may develop into thick cauliflower-like growths filling up almost the entire cyst cavity. The smallest papillary excrescences may have to the naked eye a velvet appearance. The larger papillæ are usually branched. Occasionally the connective tissue of the papillæ is myxomatous, more rarely hyaline in character. Calcification sometimes occurs in it. Tall columnar cells cover the papillæ as a rule, and the majority of these are goblet cells. The cyst contents in papillary cystadenomata consist chiefly of pseudomucin. Large numbers of desquamated and degenerating cells may be found in it. The cystadenomata of the ovaries, mammæ, and parovarium are usually papilliferous in some parts at least, while those of the liver, testis, and kidney but rarely contain papillæ.

The cystadenoma simplex is malignant only through size and position. It produces no metastases and grows only by expansion. Since it may reach an enormous size (fifty to one hundred pounds), the effects of pressure may be very important. The papillary cystadenomata represent a further departure from the normal type of gland growth, and these tumors acquire a certain tendency toward malignancy in that the papillæ may break through the cyst walls and continue to grow, spreading themselves over the neighboring tissues (in the case of ovarian cystadenomata, over the broad ligament and peritoneum, while papillary cysts of the mammæ may break through the skin). Cystocarcinomata not infrequently arise from the papillary cystadenomata, but may develop also out of the simple smooth-walled form. A gradual transition of development between adenoma, cystadenoma simplex, cystadenoma papilliferum, and cystocarcinoma may often be traced, and this fact is of great importance in so far as the question of etiology of tumors is concerned. Of the direct cause of the formation of the cystadenoma we have as little knowledge as of that of the adenomata in which they arise. They occur more frequently in females, as the ovaries and mammæ are the glands most commonly the seat of origin of these growths. They may develop at any age, but are most common at puberty and the menopause. Trauma, prolonged irritation and inflammation, etc., have, as in the case of other forms of tumors, been supposed to be exciting causes of growth. No satisfactory explanation can be given of the excessive cell secretion in some growths, whereby the tumor has the structure of a cystadenoma from the earliest beginnings; while in other cases the adenoma is but slowly and imperfectly converted into the cystic tumor.

Ovary.—The cystadenoma is the most common form of ovarian tumor, the majority of all the large cystic tumors of this organ arising from the formation of new glandular spaces and their dilatation from the accumulation of the secretions formed by the epithelial cells lining them. They arise partly out of the follicles and partly out of in-growths of the germinal epithelium. In the latter case the in-growths become separated from the surface epithelium and form gland-like structures which gradually become distended through the formation of secretions. As the cyst develops proliferation of portions of the lining epithelium into the cyst wall takes place, these separate themselves from the parent epithelium, become dilated and form daughter cysts lying in the wall of the original cyst. This process may go on indefinitely until large multilocular growths are formed. On cross-section the inner lining of the cyst walls shows furrows and depressions at those points where the in-growth preparatory to the formation of new cysts is taking place. The partition walls of many of the cysts may atrophy, thus leading to a confluence of the chambers. Remains of the atrophic walls may appear as bridge-like projections across the lumen of the cavity. This progressive formation of daughter cysts in the wall of the cystadenoma distinguishes this growth from the degeneration cysts arising from the Graafian follicle and corpus luteum. It is, however, possible that the epithelial lining of these cysts may behave in the same way as that derived from the surface germinal layer, giving rise to epithelial in-growths that lead to the same progressive formation of daughter cysts. A similar process may be set up by proliferating in-growths from the epithelium of a follicle, which is in itself not cystic. The true cystadenoma of the ovary is always in its beginning multilocular, but may become unilocular through the disappearance of the intervening septa and the confluence of the cavities. Most commonly the growth consists of one or more large cavities in the wall of which there are countless small cysts. Traces of the septa can usually be seen in the walls of the larger cysts.

As a rule, the ovarian cystadenomata form round tumors which may be more or less nodular from the unequal development of the smaller cysts. Usually there is one large, round chief cyst in whose walls are small nodules made up of smaller cysts. The whole has a smooth, shining, more or less translucent capsule which corresponds to the tunics of the follicles. Adhesions between the capsule and the peritoneum are very common, and may be very extensive and firm. These tumors may reach a very large size and surpass in weight even that of the body. As they increase in size they usually grow out from the ovary into the abdominal cavity, remaining connected to the original site of formation by a more or less well-developed pedicel; in other cases the growth is into the broad ligament, forming intraligamentous tumors, or between the ovarian ligaments (interligamentous). The ovary, as a rule, undergoes an early pressure atrophy, the pedicel of the growth being formed by the ovarian ligaments, tube, and broad ligament, all of which become very much changed from the stretching to which they are subjected. The nourishment of the growth is to a large extent supplied by the development of blood-vessels in the inflammatory adhesions which are formed between it and the neighboring structures. As the tumor increases in size it gradually rises out of the pelvis into the abdominal cavity. Torsion of the pedicel may lead to complete necrosis of the tumor, and the resulting peritonitis and intoxication caused by the absorption of poisonous products are not infrequently fatal. Retrograde changes are also very common: hemorrhage, suppuration, etc. Thin-walled cysts may burst and discharge their contents into the abdominal cavity. In this way large masses of mucin or colloid-containing material may be spread all over the peritoneal surface, often to the depth of several inches. This is partly absorbed and partly undergoes a partial organization (pseudomyxoma peritonei). Transplanted portions of the cyst epithelium lying in this may undergo proliferation and form cysts similar to the parent growth after the manner of a true metastasis. After rupture the cyst walls may become glued together by fibroblastic adhesions and complete obliteration ultimately take place.

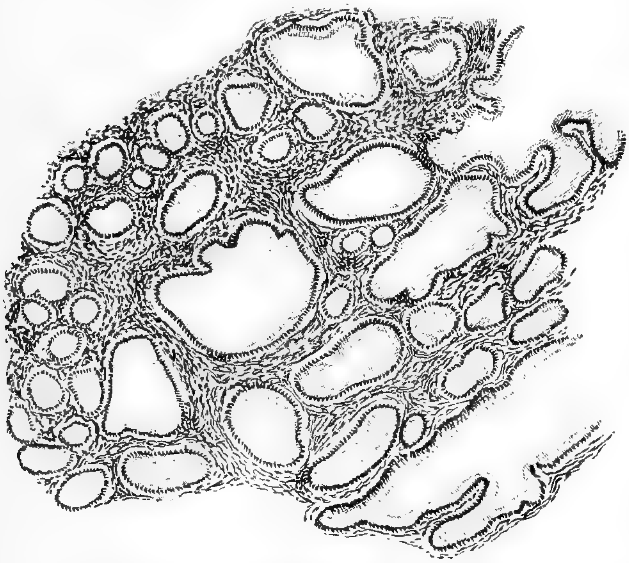

FIG. 1567.—Simple Multilocular Cystadenoma of Ovary. (Eulenberg's "Real-Encyclopaedie.")

Three forms of ovarian cystadenomata may be recognized: the cystadenoma simplex, the papilliferous form, and the cystic papilloma.

The *simple cystadenoma* has smooth inner walls lined with columnar cells which for the greater part are goblet cells, and also frequently show fatty degeneration, or necrosis. Calcareous plates may be formed in such degenerating epithelium. The contents are usually of the nature of glairy mucus, but may be serous, or thick and colloid-like. They may be much changed in character by products derived from the degenerating epithelium, by hemorrhages, or by inflammatory exudates. Pseudomucin is constantly found in the contents, but the proportion present differs very much in different tumors. It is a mucoid body which, on boiling with acids, yields a reducing substance, does not coagulate on boiling, and differs from mucin in that it is not precipitated by acetic acid. The so-called paralbumin found in the cyst contents is only a mixture of albumin and pseudomucin. The cystadenoma simplex is a benign tumor in that it grows only by expansion, and produces no hæmatogenous or lymphogenous metastases. Rarely it spreads over the peritoneum by means of implantation metastasis after rupture of its walls.

The *papillary form of the ovarian cystoma* arises in the same manner as the simple form, but differs from it in its tendency toward proliferations of its lining epithelium, not only into the wall in the formation of new cysts but also in the shape of projections into the cyst cavities. The connnective tissue of the stroma follows these epithelial buds so that a true papillary formation is brought about. This process may be observed in all stages in different cysts, from the formation of small epithelial buds giving a velvety appearance to the wall when seen by the naked eye, up to the complete filling of the cavity with a cauliflower-like mass of dendritically-branching papillæ. The proliferation of the papillæ may go so far as to lead to perforation of the walls of the tumor and the growth of the papillæ on the outer surface of the capsule, and over the neighboring peritoneum. All stages of transition forms exist between the pure cystadenoma simplex and the growths showing this excessive development of papillæ. The growth of the papillary forms is usually not so rapid as that of the simple form; it differs further from the latter in that its contents are serous, very rarely containing pseudo-mucin; and is most frequently double-sided in its occurrence, and rarely exceeds the size of a man's head. Its epithelium is occasionally ciliated. For this reason this form has been believed to arise from the parovarium rather than from the ovary. It has been shown, however, that the germinal epithelium under certain conditions becomes changed to ciliated epithelium. Psammoma-like concretions and calcareous plates are of very common occurrence in the papillæ of these growths. This form has, further, a greater tendency toward malignancy than has the simple cystadenoma. In about thirteen per cent. of cases the papillary cysts give rise to implantation metastases, and the development of carcinoma out of these growths is not infrequent. Sarcomatous changes are also said to take place in the stroma, but these cases are doubtful. Since the growth of the papillary forms is usually interligamentous, their removal is attended by greater difficulties than in the case of the cystadenoma simplex.

The *cystic papilloma* of the ovary (so-called surface papilloma) forms usually a mass about the size of an orange, having a cauliflower-like surface composed of papillæ covered with simple or ciliated columnar epithelium. These growths arise for the greater part from papillary proliferations of the surface germinal epithelium; through cystic changes in these and in the ovary the growth takes on the character of a true cystadenoma. In some cases the origin is from a ruptured papilliferous cyst whose papillæ spread over the external capsule. This form shows an especial tendency to carcinomatous change, and very frequently sets up implantation metastases. It is more likely to recur than the other forms. It is most frequently one-sided, while in the other ovary there is almost always present a papilliferous cystadenoma. Ascites is almost always associated with the surface papilloma.

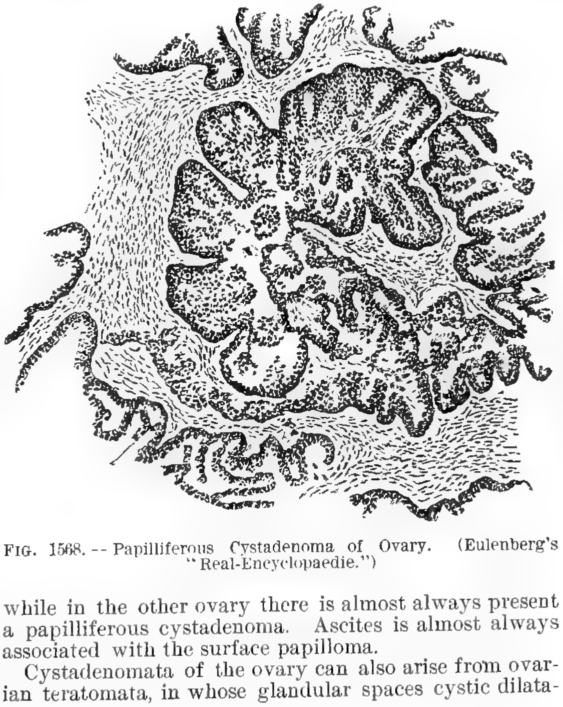

FIG. 1568.—Papilliferous Cystadenoma of Ovary. (Eulenberg's "Real-Encyclopaedie.")

Cystadenomata of the ovary can also arise from ovarian teratomata, in whose glandular spaces cystic dilatation associated with epithelial proliferation is of frequent occurrence. Dermoid cysts are very often found in association with cystadenomata arising from the germinal epithelium, usually those of the smooth-walled variety.

In the majority of ovarian cystadenomata the chief symptoms arise from pressure upon the neighboring organs. The uterus and tubes are pushed out of their normal positions, and in the case of very large tumors the abdominal organs may suffer a similar displacement. Pressure atrophy may result. Local or general peritonitis, inflammatory adhesions, ascites, hemorrhages, gangrene following torsion of the pedicel, purulent infection of the tumor through aspiration, etc., are among the important sequelæ of the development of these tumors. The treatment is wholly surgical.

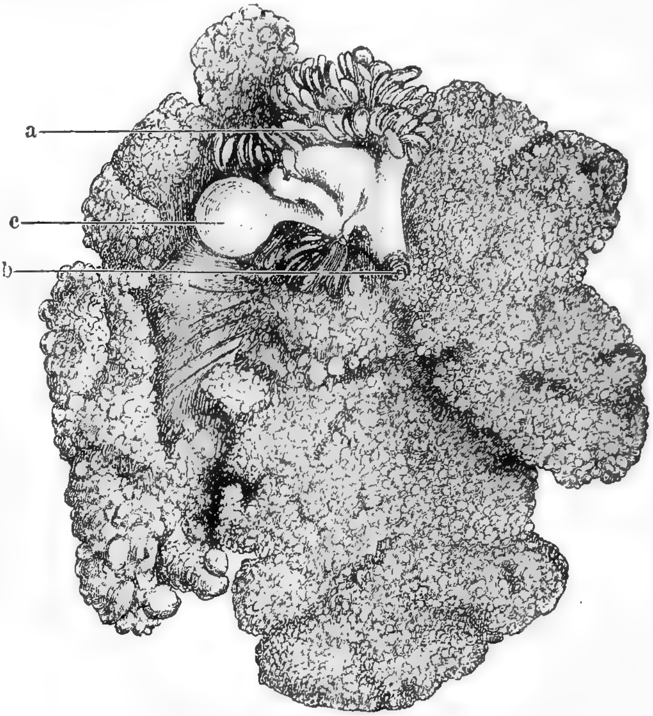

FIG. 1569.—Surface Papilloma (Cystic Papilloma) of Ovary. (Eulenberg's "Real-Encyclopaedie.")

Parovarium.—Cystadenomata of the parovarium are of much less frequent occurrence than those of the ovary. They arise through proliferation of the small canals of this organ, are intraligamentous, and seldom reach a large size; very rarely they grow around the tube. Their walls are smooth and lined with ciliated epithelium. They are benign in manner of growth. Occasionally they may rupture, but this event is, as a rule, not attended by serious consequences.

Uterus.—Cystadenomata of the wall of the uterus arising from remnants of the Wolffian duct have been described. They are not infrequently associated with myofibromata, and this association is at times so intimate that they may be designated cystadeno-myofibromata. Cystadenomata of the endometrium develop out of adenomatous polyps, but rarely reach a large size. They may become carcinomatous. Polypoid growths from the cervix, of the nature of cystadenomata, are much more common. They usually follow the glandular hyperplasia resulting from ectropion and laceration of the cervix, but may be of congenital origin. Carcinoma may develop from them.

Mammary Gland.—Next to the ovary the mammary gland is the organ most frequently affected by cystadenoma. The adenoma of the mamma is one of the most common tumors, and its gland spaces show an especial tendency to cystic dilatation. With the formation of new glandular tissue there is usually at the same time an excessive proliferation of the connective tissue of the stroma so that the resulting tumor has been called cystadenofibroma or cystofibroma. The walls of the cysts may be smooth, but are usually more or less papilliferous. The papillæ are characteristic in that they usually take the form of broad, rounded growths into the gland spaces whose lumen they almost entirely fill. On cross-section the cyst cavities appear as narrow tortuous canals lined with epithelium; many of the papillæ may be cut in such a manner that they appear as islands of connective tissue surrounded by epithelium (intracanalicular cystofibroma). Very frequently the stroma of the papillæ becomes myxomatous in character, and occasionally it shows such marked tendency toward proliferation that such growths have been designated as cystosarcomata. The cystadenomata of the mammæ are more malignant than the adenomata. The papilliferous forms may break through the skin and form surface growths. They very often become carcinomatous, and the present tendency with many pathologists is to class these growths with the malignant tumors.

Cystadenomata occur less frequently in the *liver* and *kidneys.* Their origin is either in adenomata arising from the bile ducts or kidney tubules or in cysts arising through some congenital disturbance of development. Cystadenomata of the *pancreas* are rare. They arise from the acini or collecting ducts. Cystadenomata of the *thyroid, prostate, testis, salivary glands, lachrymal gland, skin glands,* etc., are all of infrequent occurrence. Further, cystadenomata may arise from teratomata containing glandular tissue or from fœtal inclusions of glandular type. The cystic growths found very rarely in the mediastinum and abdominal wall near the umbilicus belong to this class. The latter arises from remains of the omphalo-mesenteric duct.

On the whole, cystadenomata are more malignant growths than adenomata. They cause greater local disturbance from their great size, give rise to secondary inflammatory changes, and are likely to rupture. The papilliferous forms may give rise to implantation metastases, and in all forms of cystadenomata there is a decided tendency toward the development of carcinoma. Recurrence after removal is also more common in the case of the papillary forms than with adenomata. The differential diagnosis is based chiefly upon the presence of an elastic, fluctuating tumor. Aspiration may be of aid in diagnosis and also as a means of decreasing the size of very large cysts so as to admit of their removal. The treatment is wholly surgical. The prognosis after removal of the growth is, on the whole, very favorable, but the tendency of papilliferous cystadenomata to recur must be borne in mind. When rupture of the cyst has occurred implantation metastases should always be looked for, and the same precaution should always be taken in the case of papilliferous growths of the ovary even if rupture into the abdominal cavity has not taken place. The tendency of the cystofibromata of the mammary gland to become carcinomatous makes their early removal desirable. *Aldred Scott Warthin.*

CYSTICERCUS CELLULOSÆ. See *Cestoda.*

CYSTICERCUS CELLULOSÆ CUTIS. — Multiple cysts of the skin due to cysticerci have been recognized by many observers. This disease consists of small-sized subcutaneous tumors due to the invasion of the cysticercus cellulosæ telæ (the cystic stage of the Tænia solium).

Most of the cases occur in countries where half-cooked pork is eaten. It is stated that five per cent. of the cases of Tænia solium affect the skin. The reason that few cases have been recorded is probably due to the fact that their presence causes no symptoms, and consequently the integument is not examined.

The tumors range from the size of a pea to that of a hazelnut, and may be single, but are usually multiple. They occur chiefly on the back and sides of the trunk, less frequently on the extremities. They are subcutaneous, but raise the skin into an oval-shaped tumor of a cartilaginous firmness, but withal elastic. The surface is smooth and the skin normal, unless injured by trauma or suppuration of the underlying tissues. While the animal is alive the tumor retains its elasticity, but becomes calcified into a hard nodule after its death. The differential diagnosis practically includes all subcutaneous swellings and growths.

Cysticerci also often involve the brain, and in the diagnosis any encephalopathic affection present (*e.g.*, giddiness, headache, torpor, fits), and the absence of any syphilitic history, should strengthen the suspicion as to the nature of the skin affection.

The *diagnosis* can always be confirmed by microscopical examination of one of the tumors or of the fluid, which may be obtained through puncture. Such an examination will disclose the hooklets.

William A. Hardaway.

CYSTINURIA. See *Auto-Intoxications*.

CYSTOMA. See *Cysts*.

CYSTOSCOPY. — Cystoscopy may be defined as a method of inspecting the interior of the bladder by means of an instrument introduced through the urethra. This became possible for the male bladder only when, in 1879, Nitze, of Dresden, perfected an instrument by which he could illuminate the interior of the bladder by a platinum wire heated to a white heat by electricity and prevented from burning the bladder wall by a constant current of cold water. The complications of this instrument, however, were such that the white hot wire soon gave place to a small Edison incandescent lamp, which greatly simplified the process and improved the illumination.

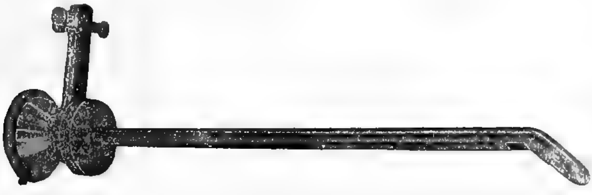
FIG. 1570.—Fenwick-Leiter Cystoscope. Lamp and windows for observation on the concave side of the instrument. Arm attached at a right angle to the handle is the movable switch to which wires from a battery are attached. (Original.)

The instrument now in use retains the essential features of Nitze's cystoscope, and consists of the following parts: a shaft, a beak, a light, a window through which the bladder wall is seen, and an optical apparatus contained in the shaft, by means of which the image is corrected and brought to the eye. The shaft is a hollow metal tube, from eight to nine and one-half inches in length, and usually of the calibre No. 22 of the French scale. At the outer end of the shaft is a funnel-shaped enlargement which contains the eyepiece of the optical apparatus and by which the instrument can be held (see Fig. 1571). The beak is three-fourths of an inch in length, and is fastened to the shaft at an angle of 145°. This beak carries the lamp, and has an aperture through which the light shines. The window, through which the bladder wall is seen, is situated on either the convex or the concave side of the angle, between the beak and the shaft. When placed on the convexity of this angle it is in the axis of the shaft and admits of a direct view of the bladder wall toward which it is pointed. When the window is on the concave side of the angle the image of the bladder wall is received by a prism which turns it at a right angle into the axis of the shaft of the instrument.

FIG. 1571.—Fenwick-Leiter Cystoscope, Second Variety. Window and lamp on the convex side of the instrument. (Original.)

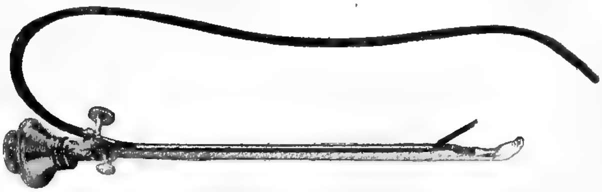
FIG. 1572.—Albarran's Catheterizing and Irrigating Cystoscope. Shows catheter in position and elevated to its full extent by the screw in the handle. (Original.)

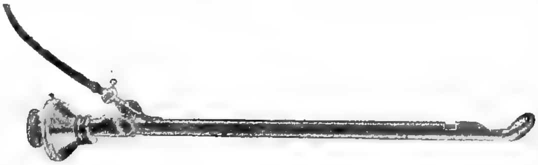
FIG. 1573.—Albarran's Catheterizing and Irrigating Cystoscope. Irrigating attachment. Water is injected into the bladder by the channel previously occupied by the catheter. (Original.)

The optical apparatus contained in a tube within the shaft has a lens just at the window in the bladder, and another at the end toward the observer.

The convergent rays which enter the little window within the bladder are deflected and carried up the axis of the tube to be received by the lens at the upper end; this lens again disperses them and presents to the eye an image equivalent to that received by the first lens. Thus a portion of the bladder wall much larger than the aperture is presented to the eye. The effect is much the same as if the eye were carried down to the lower opening and directly inspected the bladder through it.

In order to connect the lamp with the battery, the shaft is made of two tubes, one within the other, which are separated from each other by insulating material. Through them the current is carried and may be turned on and off by a switch attached to the handle. These tubes take up space and diminish the lumen of the instrument. To obviate this difficulty Otis has recently devised an instrument in which the electricity is conveyed through very fine wires.

While the principle of the cystoscope has not been altered, it has undergone many modifications to enlarge its usefulness. Thus it has been found that one of the most common causes of failure to get a good view of the bladder is the presence of blood or pus in the solution with which the bladder is filled. This may be obviated in a measure by the arrangement of an extra tube in the shaft, connecting with a stopcock in the handle, through which the fluid in the bladder can be changed from time to time without disturbing the instrument or turning off the light. Instruments thus equipped are known as irrigating cystoscopes, and the improvement is in some cases of value.

The success which attended the efforts to catheterize the ureter in the female bladder, and the information obtained in this way, naturally led to similar attempts in the male. To this end various modifications of the cystoscope have been devised to enable the operator to introduce an ureteral catheter under the guidance of the eye.

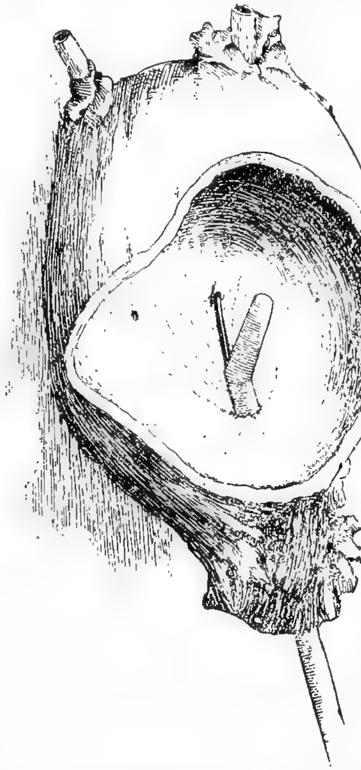

FIG. 1574.—Showing the position of a catheterizing cystoscope with window on convexity at the moment when a catheter is being introduced into the left ureter. (From F. Tilden Brown.)

The operation of cystoscopy is not difficult, but for its thorough performance some skill and patience are required. The interpretation of the conditions seen is by no means easy, and considerable experience is needed for the correct understanding of them.

The patient may be placed horizontally on his back, or in the lithotomy position, according to the individual preference of the operator. The bladder should be washed out, and the irrigation should be continued until the wash water returns clear.

If cocaine is to be used as the anæsthetic it should be introduced at this time, but the fact must be borne in mind that, while the mucous membrane of the bladder in health absorbs slowly and imperfectly, an ulcerated or diseased bladder may absorb with great rapidity. When ether or chloroform is used, the patient should be fully anæsthetized before the cystoscope is introduced.

The bladder should be distended with four or five ounces of a two-per-cent. solution of boric acid. In case of an over-distended and atonic bladder, even more than this amount of solution may be introduced. The instrument, lubricated with glycerin or other clear lubricant which will not cloud the window, is then passed in the same manner as a sound, care being taken not to start up bleeding. After the instrument has thoroughly entered the bladder, the light may be turned on, and at the same time the room should be darkened. By using the cystoscope that looks out posteriorly, the floor and fundus of the bladder, and also the sides for a considerable distance above the ureteric orifices, may be examined. Now by changing the instrument and taking the one which looks out anteriorly, the operator may inspect the front wall of the bladder and the parts above the urethral orifice. This examination should be systematic in order that no part of the bladder may be overlooked.

The limits of this article will not permit of any detailed description of the cystoscopic pictures, but will confine us to a brief consideration of the conditions in which cystoscopy may be of use.

Tumor of the Bladder.—The cystoscope affords often the most perfect opportunity for making an early and positive diagnosis of tumor. As the use of the instrument becomes more and more common it is to be expected that tumors will be detected early, before they have outgrown the possibility of thorough and radical removal. The pictures presented by tumors are often characteristic and easily understood. On the other hand, the examination is often very difficult, or indeed impossible, by reason of the hemorrhage which entirely prevents a clear picture.

It is well to remember that in a bladder not very fully distended the folds of mucous membrane may present misleading pictures closely simulating some forms of tumor. A mistake from this cause may usually be avoided by fully distending the bladder, and it is one which is but little likely to occur in the hands of an expert. With an irrigating cystoscope a jet of water may be thrown into the bladder during the examination, thus making a pedunculated tumor move in such a way that the operator may judge of the nature and extent of its attachment to the bladder wall.

Examination of an Hypertrophied Prostate.—The portions of the prostate which project back into the bladder can be quite thoroughly and satisfactorily examined through the cystoscope. The knowledge thus obtained may be of decided value in determining the operative procedure appropriate to each case.

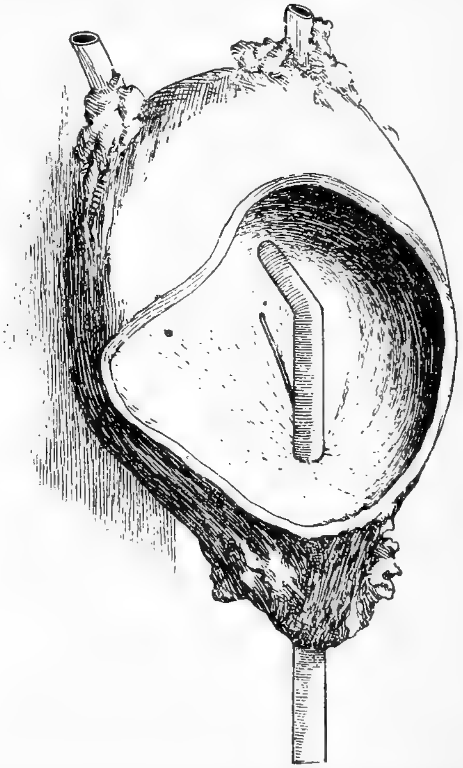

FIG. 1575.—Showing the process of catheterizing the left ureter through a cystoscope having window on the concavity. (From F. Tilden Brown.)

Sacculated Bladder.—There are certain cases of sacculated bladder in which the cystoscope is a great aid in diagnosis. The pockets may contain stones or give rise to conditions resulting in the formation of stone, and in such cases an early and accurate diagnosis is difficult or impossible without the aid of the cystoscope. A more frequent use of this instrument might lead to a more intelligent treatment of the obscure conditions.

Ulceration of the Bladder Wall.—It is rare to see the bladder wall ulcerated except as the result of malignant disease or tuberculosis. It is usually possible to make the diagnosis of tuberculosis without the aid of the cystoscope; and this is fortunate, for the manipulations of a thorough cystoscopic examination often greatly aggravate the discomforts of a tuberculous patient and in some cases even seem to hasten the course of the disease. This is especially due to the danger of adding a mixed infection to the existent tuberculous process.

Examination of the Ureter.—Inspection of the ureteric orifice is possible through the cystoscope and may afford valuable information as to the condition of the kidneys. In hæmaturia or pyuria, for example, a cloudy jet of blood or pus from the ureter convicts the corresponding kidney of being the seat of the hemorrhage, or of some inflammatory process. The desire to extend the examination further and to get still more exact information as to the condition of each kidney has led to the use of ureteral catheters, through the cystoscope. Brenner, Caspar, Albarran, Otis, Brown, and others have devised a modification of the cystoscope which makes this procedure possible. For a more complete discussion of this subject the reader is referred to the article on *Catheterism.*

Detection of Foreign Bodies.—The cystoscope is occasionally useful in demonstrating the presence of foreign bodies in the bladder. In this way pins, silver-wire sutures, and silk sutures which were working their way into the bladder have been seen and removed.

Arthur T. Cabot.
Hugh Cabot.

CYSTS. (See also *Cystadenoma.*)—A cyst is a circumscribed cavity containing a more or less fluid substance, or in rare cases gas, shut off from the neighboring tissues by a more or less independent wall, and owing its origin to pathological processes. To this definition there are, however, a number of exceptions. Pericardial, pleural, and peritoneal effusions, tuberculous cavities, abscess caverns, sinuses, etc., as well as simple dilatations of the hollow organs of the body (stomach, colon, bladder, etc.), in which the normal wall as well as the form of the organ is preserved, are not as a rule designated as cysts. A distinction is also made by some writers between cysts possessing a well-defined wall and those whose wall consists only of the surrounding tissue, the latter being termed cystoid. On the other hand a distinction must be made between the true cysts and the cystic neoplasms. The latter are to be classed as cystomata or cystadenomata. It is very difficult, however, to fix the boundary line between the cyst and the cystoma. In the development of every cyst a certain degree of proliferation of its wall must take place to compensate for the increasing size of its cavity, else defects in its wall would result. This tendency of the cyst wall to proliferation is more marked in some cases of cyst formation than in others, consequently it sometimes becomes very difficult to fix the exact nature of the cyst. As a general point of differentiation it may be taken that all cystic growths which through the proliferation of the elements of their walls constantly form new cysts are to be classed with the cystomata. In connection with such growths there is usually a pathological formation of new gland tissue to which the cystic change is almost always secondary. The character of the growth is therefore more properly expressed by the term cystadenoma. In the true cyst the proliferation of the cyst wall is confined to that of the original cyst and there is no progressive formation of new glandular tissue. It must, however, be borne in mind that cystomata very frequently take their origin from simple cysts.

Cysts may vary in size from a pinhead to a man's head and occasionally much larger. They may consist of but one cavity (simple or unilocular cyst), or they may be many-chambered (compound or multilocular cysts). The chambers of a multilocular cyst are usually very irregular in size and shape, and may or may not communicate with each other. Communication between the cavities may occur primarily in cases in which an entire acinous gland becomes changed into a cyst, as may happen in the case of the salivary glands. Secondary communication may be established through rupture or atrophy of the partition walls. Complete destruction of these transforms a multilocular cyst into a unilocular. On the other hand, a cyst of a single cavity may through proliferation of its walls become changed to one of several or many chambers. Obliteration of a cyst cavity may result from organization or solidification of its contents, or rupture of the cyst may be followed by its collapse and subsequent union of its walls through fibroblastic adhesions. The inner wall of the cyst cavity may be smooth (simple cyst), or may be papillary (papilliferous or proliferous cyst). Cysts in their occurrence may be single or multiple. Multiple cyst formation in a number of adjacent cavities may assume the appearance of a multilocular cyst through the atrophy of the intervening tissues.

The essential elements of the cyst are the cyst wall and the cyst contents. The latter must be different in nature from the former, but both bear certain definite relations to each other. Either one or the other may be the primary agent in the formation of the cyst. In the case of the liquefaction of necrosed tissues or in the formation of a capsule around a parasite the wall is developed secondarily to the contents, while in other forms of cysts the contents are the result of secretion by the elements of the cyst wall. In these cases, however, the retention of secretions and the consequent stretching of the wall are the factors which excite further proliferation in the elements of the wall.

As a rule the cyst wall consists of a connective-tissue membrane of greater or less thickness separating the cyst contents from the neighboring tissues. It may be thick enough to be visible to the naked eye, or may be evident under the microscope as a very delicate fibrous layer, or only as a thickened layer of the surrounding tissues, while in other cases the cyst contents may lie in direct contact with these without any proper intervening membrane. Very frequently the cyst wall is so independently developed as to render it possible for the cyst to be easily shelled out from the surrounding tissues. In other cases the wall may become thickened through inflammatory processes and so intimately adherent to the neighboring structures that its separation from them becomes difficult or impossible. In a general way the thickness of the cyst wall will depend both upon the age of the cyst and upon the degree of pressure within it. In the early stages of formation the cyst may possess no definite wall, while later a thick fibrous capsule may gradually develop. On the other hand an originally thick capsule may be thinned from a great increase of pressure within the cyst. Deposits of fibrin, lime salts, etc., upon the inner surface of the wall may cause its apparent thickening. The connective-tissue capsule of the cyst may have either an epithelial or an endothelial lining, or the cyst contents may lie in direct contact with the connective tissue of the wall or with the surrounding tissue. This will depend chiefly upon the anatomical origin of the cyst, the character of the inner lining of the capsule being the same as that of the cavity from which the cyst arose. Epithelium will be found only in those cysts which arise from spaces originally lined with epithelium, and from the character of the epithelial cells lining the cyst it is possible within certain limits to tell its origin. Many changes, however, take place in the character of the lining cells: originally tall columnar cells may become cuboidal or flattened, ciliated cells may be changed to simple columnar or flattened, while a single-layered epithelium may become stratified through proliferation. Increase of pressure within the cyst is the chief factor in producing these changes. For this reason the true character of the lining epithelium is best preserved in the cysts of smallest size. Under certain conditions these changed forms of epithelium revert to their original type. Cysts formed in connective tissue or from dilatation of blood or lymph spaces will be lined with endothelium. In the first case the endothelium arises from the proliferation of the endothelial cells lying in the connective-tissue spaces.

Retrograde changes are of very frequent occurrence in the cyst wall and the cells lining it. Mucous degeneration, as well as hydropic and fatty degeneration of the lining epithelium, is the most common. Desquamation and necrosis also occur, as well as pressure atrophy. Corpora amylacea and colloid-like substances are also found in cysts as the results of pathological secretion of the lining cells. In the connective-tissue capsule there may occur inflammatory processes of varied kinds, suppuration, hemorrhage, calcification, hyaline change, and even bone formation. Calcareous plates may be formed in the cyst wall or the entire wall may be completely calcified. Very rarely amyloid is found in cyst walls after inflammatory processes. As a result of changes in the capsule the lining of the cyst undergoes degeneration following the disturbance of its nutrition. Obliteration of the cyst may result from extensive changes in the wall.

The content of cysts varies greatly according to their origin. It may be serous with greater or less albumin content, or it may contain mucin, pseudo-mucin, albumose, etc., or it may be colloid-like, hemorrhagic, purulent, or contain fat, fatty-acid crystals, cholesterin, blood pigment, etc. To the naked eye its appearance may be thin and transparent, or thick, turbid, opaque, varying in color from red, brown, greenish, or gray, to yellow and white. The consistence may be stringy, gelatinous, waxy, slimy, pultaceous, greasy, etc. In rare cases the cyst may contain only air or gas. The epithelium lining cysts produces a secretion somewhat analogous to that of the gland from which it has its origin, but owing to the retrograde changes occurring in the epithelial cells the chemical nature of the secretion comes to differ greatly from that of the normal. According to the nature of these changes it may become serous, mucous, colloid, etc.; if exudates from the cyst wall are added to it the content may become fibrinous, purulent, albuminous, etc.; or in case of hemorrhage into the cyst it may contain the remains of red cells or blood-pigment granules. The reaction of cyst secretions is usually weakly alkaline, but it may be neutral or acid in rare cases of retention of an acid secretion. Cysts arising from the degeneration of tissues or tumors may contain portions of tissue showing sufficient structure to aid in the differential diagnosis. In cysts formed by parasites portions of the parasite may be present. In the case of cystic abdominal tumors the character of the cyst contents is of great importance in the differential diagnosis.

According to their origin cysts may be divided into:

1. Retention cysts.
2. Follicular cysts.
3. Proliferation cysts.
4. Degeneration cysts.
5. Endothelial cysts.
6. Congenital cysts.
7. Inclusion cysts.
8. Foreign-body cysts.
9. Parasite cysts.
10. Air or gas cysts.

Retention Cysts.—These arise through the dilatation of gland spaces or ducts caused by the retention of secretion due to some obstruction to the normal outflow. This is the most common form of cyst and may arise in any gland of the body possessing a duct or lumen, provided that an actively secreting parenchyma still remains behind the point of obstruction. Such cysts are therefore lined with epithelium resembling in character that of the gland in which they arise. Retention cysts lined with endothelium may arise from lymphatics, lymph spaces, synovial membranes, or tendon sheaths. The contents of retention cysts depend upon the nature of the tissue in which they are formed and upon the secondary retrograde changes present. The causes leading to the obstruction or closure of gland ducts are very varied in nature: inflammations in the gland or neighboring tissues, cicatricial contraction, thickening of secretions, calculi, new growths in or around the gland, etc. The gland duct may also be partially closed during a resting period, so that when the gland is suddenly called into activity the inadequacy of the outflow leads to a cystic dilatation. As the secretions collect behind the point of obstruction, the gland or duct becomes dilated and with the stretching of the wall there is usually a compensatory hyperplasia of the gland wall.

Retention cysts are most commonly found in the hair follicles and sebaceous glands of the skin, glands of Bartholin, mucous glands of the alimentary tracts, uterine glands, epididymis, kidney tubules, and mammary gland; less frequently in the sweat glands, biliary ducts, pancreas, salivary glands, etc. Cystic dilatation of the larger canals, ureters, vermiform appendix, Fallopian tubes, etc., may also be caused by obstruction and retention of pathological secretions and exudates.

Follicular Cysts.—Closed glandular cavities having no outlet, such as those of the thyroid, ovary, parovarium, etc., become cystic when an excessive amount of secretion is formed by their walls. Such cysts are extremely common in the ovary and parovarium, being found in practically every woman after the age of thirty. They are usually of small size but may become very large. They are lined usually with a single layer of columnar cells and contain a mucoid or colloid-like substance. This may present great alterations in character due to secondary pathological changes in the cyst wall.

Proliferation Cysts.—As the retention or follicular cyst enlarges there must take place also a compensatory increase of the tissue elements of its wall, or else rupture from excessive thinning would eventually take place. Cyst formation is therefore not entirely of the nature of a retrograde change, but involves a certain degree of proliferation. It is consequently difficult to draw a definite line between simple proliferating cysts on the one hand and cystic neoplasms on the other. As true tumors of the latter class (cystomata or cystadenomata) may be classed all cystic growths which through the proliferation of their walls constantly form new cysts. Preceding this new cyst formation there is usually a pathological formation of new gland tissues to which the cystic change is secondary. As mentioned above such growths are therefore more properly classed as cystadenomata. Cystic tumors may also arise from newly formed lymph and blood vessels, but these are to be classed with the angiomata. As true proliferation cysts are to be regarded those unilocular cysts which become multilocular through the proliferation of their walls, at the same time increasing greatly in size; or those cysts whose walls proliferate into the lumen of the cyst, forming papillary excrescences on the inner surface of the cyst wall. Proliferation cysts occur chiefly in the ovary, parovarium, kidneys, and cervix uteri. Between them and the true cystoma there is a gradual transition.

Degeneration Cysts.—Cystic spaces are very frequently formed by the liquefaction of necrosed portions of tissues or organs. They may possess no definite wall, or the space may be surrounded by a connective-tissue capsule which in some cases is lined with endothelium derived from the endothelial cells of the connective-tissue spaces. The cyst may contain portions of necrosing tissue-elements whose structure is sufficiently preserved to admit of identification. Degeneration cysts may arise as sequelæ to anæmic infarctions, especially those of the brain. In the ovary they occur within certain limits as a physiological degeneration of the corpus luteum and also of the Graafian follicle after the menopause. Large extravasations of blood in the tissues, chronic abscesses, old tubercles, gummata, etc., may also become liquefied and form cysts. Degeneration cysts occur also in the bone marrow of old age, and in the thyroid, pancreas, kidneys, etc. They are also very commonly present in quickly growing malignant tumors following simple necrosis, fatty or mucous degeneration. In these cases the content of the cyst is usually cloudy or turbid, containing blood pigment and remains of tumor elements. Such degeneration cysts are especially common in myxomata and sarcomata, sometimes occurring to such a degree as to warrant the employment of such terms as cystomyxoma, cystosarcoma.

Endothelial Cysts.—Degeneration cysts lined with endothelium may be formed by the proliferation of the endothelial cells of the connective-tissue spaces. Retention cysts with endothelial lining may arise from blood-vessels, lymphatic vessels and spaces, tendon sheaths and synovial membranes. The so-called ganglion, hygroma, etc., may be placed in this category. In these cases the cyst is usually formed by the shutting off of some portion of a cavity by inflammatory adhesions or constrictions, and the dilatation of the sac so formed through the accumulations of inflammatory exudates. In the case of the ganglion the cyst is formed by a myxomatous degeneration of the connective tissue in the neighborhood of the joints, and derives its endothelium from that of the lymph spaces. It is partly a new formation and partly a degeneration. The cystic hæmangiomata and lymphangiomata belong to the neoplasms and are not to be placed in this category.

Congenital Cysts.—Remains of fœtal clefts, canals, and fissures in normal locations or misplaced fœtal inclusions may become cystic as a result of proliferation of their walls excited by trauma, inflammation, etc., or from excessive formation of secretion. Such cysts occur in the branchial clefts, urachus, parovarium, remains of the Wolffian body, Müller's ducts, etc. The dermoid cysts and cystic teratomata are usually classed with neoplasms. Analogous to the cysts arising from fœtal inclusions are those arising from the implantation of epithelium occurring rarely as the result of trauma, inflammation, or operation (inclusion cysts.)

Inclusion Cysts.—Through traumatic or surgical displacement of portions of epithelium into mesoblastic tissues cysts may be formed from the resulting proliferation of the included epithelium. Kaufmann's experiments in enkatarrhophy are well known. He found that the inclusion of portions of a cock's comb was followed by the formation of cysts lined throughout with epithelium and containing material resembling that found in atheromatous cysts. The growth of these cysts continued until a certain limit was reached when they remained stationary. Similar cysts have been observed in the human body arising from implantations of portions of epithelium after trauma to the skin and scalp. They are found more frequently in the scars of burns than after wounds. The writer has observed a case of multiple cyst formation after the removal of a portion of the jaw in a case of giant-cell sarcoma. The cysts, the largest of which was of the size of a hen's egg, were lined with stratified squamous epithelium most probably derived from the mucous membrane of the mouth. Such dislocated portions of epithelium do not possess the intrinsic capacity for unlimited growth as seen in the cell nests of epiblastic tumors. Traumatic epithelial cysts must be thoroughly removed, otherwise they may recur.

Foreign-Body Cysts.—Around foreign bodies embedded in the tissues a capsule of connective tissue may be formed. This may undergo proliferation while degenerative changes may occur within the cyst contents. In this manner cysts may arise that partake of the nature of both degeneration and proliferation cysts. Such cysts contain in addition to the primary cause, necrosed tissue and pathological exudates from the wall.

Parasite Cysts.—Aside from the capsule which may be formed around a parasite, certain organisms such as the cysticercus and echinococcus may be found in the human body in the cystic stage of their development. Around the cyst formed by the parasite itself there is usually developed a connective-tissue capsule. Only rarely are the parasite cysts found free in the tissues or in the body cavities, the cysticercus being occasionally found in the meninges and ventricles of the brain. Parasite cysts may contain characteristic portions of the parasite or may be sterile.

Air and Gas Cysts.—Cyst-like cavities filled with air may arise from the shutting-off of portions of emphysematous lungs. Air-containing diverticula are found rarely in the pockets of Morgagni, and the mucous glands of the trachea and larynx may undergo cystic dilatation from air forced into them under high pressure. Cysts containing gas are occasionally found in the mucous membrane of the vagina. According to Zweifel the content of these cysts consists of trimethylamine. Eppinger and others hold that the condition is only an emphysema of the vaginal wall. According to Chiari's investigations the cysts are dilated lymph spaces lined with endothelium which not infrequently produces giant cells. The origin and nature of the gas filling the cyst are unknown. Similar gas cysts have also been observed in the wall of the intestines and in peritoneal adhesions. Cystoid spaces containing gas are also found throughout the body in cases of infection with the Bacillus aërogenes capsulatus. The gas found in gas cysts is sometimes inflammable.

Occurrence.—The occurrence of cysts in the human body is very widespread. They may be found in practically every organ and tissue. The most important distribution is as follows:

Fœtus.—Small cysts in the amnion are occasionally found. They are the result of a myxomatous hyperplasia of the mesenchyma. They are small and without clinical significance. Small cysts of this membrane lined with epithelial-like cells have also been described and called dermoids, but their exact nature is unknown. Cystic change of the chorionic villi due to a myxomatous degeneration of the villous stroma is relatively common. It may affect the chorion as a whole or be limited to single villi (bladder mole, grape mole, etc.). Larger cysts of the chorion have been observed in a few cases. These may have their origin in the liquefaction of placental infarcts, or they may arise from disturbances in the development of the chorion and amnion. Retention and degeneration cysts may be formed in the internal organs of the fœtus, especially in the liver and kidneys. Their etiology is obscure; they are in part explained by errors of development and in part by inflammatory processes occurring in intra-uterine life.

Bones.—The cysts most commonly found in bones are of the nature of degeneration cysts. They occur chiefly in osteomalacia and in the osteoporosis of old age, arising from the liquefaction of the marrow, and may reach such a large size that only the outer shell of the bone is preserved. The cyst contents may be clear, cloudy, or hemorrhagic, frequently containing much liquid fat. As a rule they possess a connective-tissue capsule, and from this capsule there occurs sometimes in osteomalacia a reparative proliferation of connective tissue. Degeneration cysts are also of very frequent occurrence in tumors arising either from the periosteum or from the medulla but more often in those from the latter. They occur most frequently in the myxoma and sarcoma of bones, but also in synchondromata and fibromata as well as in metastatic carcinoma of bone. A cystoid cavity, often multilocular, usually results from the degeneration of these tumors, the wall of the cavity consisting of tumor tissue or bone. Not infrequently there is a new formation of bone in the wall of the cyst. Cystic dilatation of the antrum of Highmore occurs rarely. Proliferating cysts are seen rarely in the jaws; they arise from the tooth sacs (alveolar cysts). Echinococcus cysts may occur, usually in the long bones, pelvis, skull, vertebræ, and phalanges. They may occur as exogenous cysts beneath the periosteum, and a few cases have been reported in which the surface of the femur and tibia was completely covered with such cysts. Through pressure the bone atrophies and disappears, or necrosis takes place, thus often leading to spontaneous fracture. When originating in the medulla echinococcus cysts resemble myelogenous tumors for which they are usually mistaken. The cysticercus is only very rarely found in bone.

Muscle.—Degeneration cysts occur in old extravasations and in myxomata and sarcomata arising from the intermuscular connective tissue. Echinococcus cysts are rare; those produced by the cysticercus are more frequently found. Cysts of small size are formed by trichina spiralis.

Tendons, Bursæ.—Cysts found in these structures are usually lined with endothelium (hydrops, hygroma, ganglion, etc.). Degeneration cysts may arise from the liquefaction of hæmatoma contents. These are likewise usually lined with endothelium.

Nervous System.—Cysts lined with endothelium are found rarely in the dura (dural hygroma). Echinococcus and cysticercus cysts are both found in the meninges, the latter as solitary cysts of the size of a pea or in large lobulated cysts containing grape-like clusters of daughter cysts both inside and outside (C. racemosus.) These cysts are for the greater part sterile, but some may contain a single scolex. About them extensive proliferation may be excited. Echinococcus cysts are rare in the brain substance while cysticerci are of relatively frequent occurrence. The most common cysts of the brain substance are those produced by degeneration of infarctions or extravasations. As a rule these possess no independent wall; they are filled with a fluid similar to the cerebro-spinal. Degeneration cysts are also common in brain tumors, especially in the glioma. Cerebellar cysts may arise from diverticula of the fourth ventricle. Cysts are very frequently seen in the choroid plexus; they vary in size from a pea to a cherry. The cyst wall consists of delicate connective tissue containing fine vessels, is covered outside with polygonal epithelium, and is lined with endothelium. Delicate fibres of connective tissue containing vessels not infrequently are stretched across the cyst cavity. Similar cysts are also found in the pineal gland and hypophysis, those of the latter being sometimes lined with ciliated columnar cells. Their significance is unknown. Cysts of the brain and its membranes may also arise from errors of development (encephalocele, meningoencephalocele, etc.). Similar cysts are found also in the spinal cord (spina bifida, etc.). Cystic degeneration of Pacinian corpuscles has been observed by the writer.

Special-Sense Organs.—With the exception of insignificant retention cysts, cysts are not found in the ear. Cysticercus cysts may occur in the eye. Small cysts lined with stratified epithelium are found in the iris after injuries to the cornea and have been explained as being due to implantations of corneal epithelium. Small dermoid cysts have been observed in the cornea. The writer has observed retention cysts in an adenoma of the lachrymal gland.

Skin.—The most common cysts of the skin are the retention cysts of the hair follicles and sebaceous glands (atheroma, sebaceous cyst, etc.). They occur most frequently in the scalp, skin of the neck, and forehead. Dermoids are found in the subcutaneous tissue, as are also echinococcus and cysticercus cysts. Small miliary cysts of the sweat ducts occur under certain conditions, and in many of the diseases peculiar to the skin cyst-like spaces of varying nature may arise. Cystic dilatations of remains of the branchial clefts may be found beneath the skin in the neck. In rare cases cysts arising from the omphalo-mesenteric duct may be formed in the abdominal wall.

Alimentary Tract.—Retention cysts of the mucous glands may occur in any part of the mucosa of this tract from the lips to the anus. Small ones may be formed in acute catarrhal processes, larger ones in chronic catarrhs, dysentery, etc. Small cysts embedded in the muscle of the tongue are occasionally found. The ducts of the salivary glands may become obstructed and thus give rise to cystic dilatation; the tumor usually presenting itself in the floor of the mouth, beneath the tongue (ranula). Dermoids are also found in the tongue and mouth. Cysts arising from the tooth follicles may reach the size of a hen's egg (alveolar cysts). Cystic dilatations of the vermiform appendix may occur. Cysts connected with the intestine may arise from remains of the omphalo-mesenteric duct.

Respiratory Tract.—Retention cysts of the mucous glands are found on the epiglottis, and in the mucosa of the larynx and trachea, more rarely in the bronchi. Rarely air cysts may be formed in these glands as the result of air being forced into them under high pressure. These may press outward between the trachea and the œsophagus. Dermoids have been observed in the lungs, but it is probable that these arose in the mediastinum. Echinococcus cysts of the lungs are very rare. Air cysts arise from the formation of emphysematous diverticula and their subsequent shutting off.

Thyroid.—Cystic degeneration of the thyroid through increased formation of colloid is of very frequent occurrence (struma cystica). These cysts contain colloid of varying color and consistence. Hyaline change and calcification are of frequent occurrence in the walls of these cysts, and the formation of true bone has also been observed in them (struma cystica ossea). Similar cysts in the thyroid region arise in accessory thyroids. The writer has observed in a case of acromegaly a cystic change in the parathyroids. The cysts varied in size from a pinhead to a pea, and contained an albuminous fluid which bore no resemblance to colloid.

Heart.—Both cysticercus and echinococcus cysts have been observed in the pericardium. Degeneration cysts in new growths are also found here. In adhesive pericarditis cyst-like cavities may be formed between the adhesions, and these may become lined wth hypertrophic endothelium presenting a gland-like appearance. In the heart muscle itself both the echinococcus and the cysticercus have been found.

Spleen.—Large degeneration cysts may follow anæmic infarction. Echinococcus cysts have also been observed in this organ, more rarely the cysticercus. Small cysts containing serous fluid are found rarely near the capsule. They are lined with endothelium and are supposed to be due to peritoneal inclusions.

Liver.—Cyst-like dilatation of the gall bladder is not uncommon from obstruction of the duct by gall stones. Retention cysts of the smaller bile ducts in the liver substance are not rare. These usually possess a thin wall and contain a clear or bile-stained serous fluid; in other cases the walls are thick and the contents made up of thick bile, fat, and cholesterin. As a rule the cysts are lined with a low columnar or flattened epithelium derived from that of the bile ducts. All gradations of size between these small cysts and those attaining the size of a fœtal head may be found. In some cases the number is so great that but little of the liver parenchyma is left (cystic degeneration of liver). Associated with this a similar condition may be found in the kidneys. Such cases are very frequently of congenital origin, and are most probably to be explained by some disturbance of development during fœtal life. Solitary cysts containing clear fluid and lined with ciliated cells occur rarely in the liver parenchyma. Their significance is unknown. The most important cysts of the liver are those caused by the echinococcus; they occur more frequently in this organ than in any other part of the body. Degeneration cysts occur in tumors of the liver, especially in secondary sarcomata.

Pancreas.—Cysts of the organ may arise from obstruction of the pancreatic duct (ranula pancreatica). Degeneration cysts following necrosis, gangrene, hemorrhage, etc., are not uncommon. In other cases pancreatic cysts may arise from disturbances of development. They may reach a very large size and as a rule show a tendency to proliferation. From such cysts multilocular cystomata may develop.

Adrenals.—In the hyperplasias of these organs—known as adrenal struma—degeneration cysts occur after the growth has reached a certain degree of development. Necrosis of the central portion of the growth takes place so that the only living tumor tissue is found as a narrow zone just beneath the capsule. Softening develops in the necrosed portion and in time a cyst of large size may result. The contents are usually reddish or brown in color and of a pultaceous consistence. Rupture of the cyst may take place. Such cysts may form in the ac cessory adrenal tissue found in and about the kidneys, in the liver, etc., and in the adrenals of Marchand found in the broad ligament and near the testis. Adrenal tissue has been found in the walls of cysts of the broad ligament.

Kidneys.—After the ovaries the kidneys are the organs in which cysts are found more frequently than in any other part of the body. They may be solitary or numerous, large or small; they lie usually just beneath the fibrous capsule, having a thin wall and containing a clear yellowish fluid (so-called urine cysts). They are found also throughout the kidney substance, and may show all gradations of size from a pinhead to a hen's egg. They are lined with flattened epithelium which in the older cysts may have undergone degeneration. In these the contents may resemble colloid, and are not infrequently mixed with blood pigment. These cysts are retention cysts of the glomeruli and tubules, and are most commonly found in chronic nephritis, about infarct scars, and in all conditions of the kidney in which the connective tissue is increased. A few of these simple retention cysts are found in the kidneys of almost every individual after the age of forty. Congenital cysts of the kidney are found in the new-born in whom they sometimes reach a very large size and interfere with delivery. Extensive cystic degeneration of the kidneys, usually in association with a similar process in the liver, occurs in adults and is probably the result of some congenital anomaly. The organs may appear as if honeycombed, very little of the secreting structure being left. Cystic degeneration of sarcomatous tumors of the kidneys may occur and may be mistaken clinically for ovarian cysts. Proliferation cysts and dermoids have been described. Both cysticercus and echinococcus cysts occur rarely, the latter sometimes reaching a very great size.

Peritoneum.—Small cysts with serous contents are frequently found in the peritoneum, especially in the neighborhood of the female genital organs. They are found also in inflammatory adhesions, but may develop without preceding inflammation. In certain cases the entire peritoneum may be covered with small cysts varying in size from a pea to a walnut, many of them being attached to slender pedicles. They possess a delicate wall, and their contents may be either serous or chylous. They are partly lymph cysts arising from dilated lymph vessels, and partly of the nature of cystic lymphangiomata. Serous cysts and gas cysts similar to those of the vagina have been observed in the serosa of the intestines and in peritoneal adhesions. The cysticercus forms harmless cysts in the peritoneal cavity, but those of the echinococcus may reach a very large size.

Female Genital Tract.—Cystic dilatations of constricted portions of the canal of Nuck sometimes occur. These may present themselves in the labia majora as large cysts lined with endothelium derived from the peritoneum. Atheromata and lymphangiectatic cysts are very common in the vulva. Retention cysts are not infrequently seen in the glands of Bartholin and may reach the size of a goose egg. Smaller cysts with serous or mucous contents are sometimes found in the hymen and around the entrance to the vagina. The gas cysts of the vagina have been described above. Retention cysts are extremely common in the mucous glands of the cervix (ovula Nabothi), especially in cases of ectropion and erosion following laceration of the cervix. They are almost constantly present in women past the menopause. These cysts show an especial tendency toward proliferation and from them cystadenomata not infrequently arise. Retention cysts of the glands of the endometrium are very common, especially in chronic endometritis in which disease the cysts may be so large and numerous as to warrant the name of cystic endometritis. A tendency to proliferation is observed here also. Degeneration cysts occur with great frequency in the uterine myofibromata and sarcomata. Cystic dilatation of the tubes may occur as a result of obstruction or constriction (hydrops tubæ cysticus). By confluent growth with ovarian cysts tubo-ovarian cysts may be formed. The small hydatid cysts occurring almost constantly near the fimbriæ are without significance except when they reach a large size or show a tendency to proliferation. On the surface of the tubes and broad ligament there are occasionally seen in women past the menopause large numbers of small colloid cysts which have been thought to be degenerating ova. The cysts of the ovary and parovarium are of endless variety: degeneration cysts of Graafian follicle (hydrops folliculi Graafianii) and corpus luteum, follicular cysts, proliferation cysts, dermoids, cystic teratomata, etc. The so-called "kleincystische" degeneration of the ovary is probably to be looked upon as an early ripening of a large number of follicles, a form of follicular hypertrophy. In some cases the dilatation of the follicles is the result of inflammatory processes. Cysts in the broad ligament may arise from the remains of Müller's ducts or from the adrenal tissue (Marchand's adrenals) which may be found there. The cysts of Kobelt are dilatations of portions of the parovarium. Echinococcus cysts arising from the ovary and uterus have been observed.

Male Genital Tract.—Cysts are very common in the head of the epididymis or its neighborhood. They may have a milky content (galactocele) or may contain spermatozoa (spermatocele). The wall of such cysts may be lined with ciliated, simple columnar or flattened epithelium. They occur almost constantly in old age without significance, but in youth they are usually the result of inflammation and may be numerous and reach a large size. Occasionally they arise without preceding inflammation. They arise from the vasa aberrantia. The so-called hydatids of Morgagni are small and practically, without significance. Cystic dilatation of the tubules of the body of the testis may be caused by new growths. Degeneration cysts are also found in primary tumors of the testis. Dermoid cysts and cystic teratomata are relatively common while the parasite cysts are but rarely found. Cystic dilatation of the spermatic cord and seminal vesicles is not uncommon. Retention cysts are found in the prostate and urethral glands. Cysts may also arise in the neighborhood of the prostate from the remains of Müller's ducts. Small cysts are occasionally seen in the prepuce and scrotum.

Mammary Gland.—Retention cysts occur in this organ very frequently. According to the character of their contents they are called "milk cysts," "butter cysts," "soap cysts," etc. Proliferation cysts are also very common and from them the various forms of cystofibromata arise. Degeneration cysts occur in case of malignant tumor. Cystic degeneration of the gland within certain limits occurs as a senile change.

Cysts may be found at any age but are most common in late adult life and old age. Within certain limits cyst formation in the kidneys, ovaries, testicles, uterus, etc., may be regarded as a part of the physiological atrophy due to senility. The cysts found in early life are most frequently those due to congenital errors of development. Such cysts in connection with the genital tract may at puberty show marked tendency to proliferation and for this reason first manifest themselves at this time. The menopause is also a period of active cyst formation in the female genital tract. As a rule the growth of cysts is slow, but in some cases the rapid and excessive formation of secretions or exudations within the cyst may lead within a short time to the formation of a cyst of enormous proportions. The degenerative changes so frequently occurring in the walls of cysts very soon lead to marked changes both in and around the cyst. Through the proliferation of the wall following inflammation or through solidification and organization of the cyst contents many cysts become obliterated. This fact is sometimes taken advantage of by the surgeon, who, by the injection of some irritating fluid into the cyst cavity, produces an inflammation within the cyst wall in the hope that the resulting proliferation may obliterate the cyst.

The true cysts are benign growths in that they do not produce metastases. The proliferation cysts alone are allied to the cystic neoplasms, and since the latter so frequently arise from them they may be regarded as intermediate forms between the cysts and cystomata. Cysts become malignant by virtue of size and position, and the secondary changes which they undergo. Cystic degeneration of the placenta may lead to abortion. Cysts of the meninges and brain may produce very serious disturbances on the part of the nervous system. Large atheromata of the scalp may cause a pressure atrophy of the underlying portions of the cranium. Cysts of the neck and respiratory tract may interfere seriously with respiration and deglutition. Cysts of the internal organs when of very large size may produce fatal results through pressure or rupture. Echinococcus cysts in the heart may give rise to extensive metastases or may cause sudden death through rupture of the heart wall. Rupture of cysts into any of the body cavities may give rise to widespread inflammations of serous surfaces. This occurs most frequently in the case of large ovarian cysts. Occasionally the mucous contents of these cysts may be spread in a thick layer over the entire peritoneum, becoming partly organized (pseudo-myxoma of peritoneum). Cysts of the liver, pancreas, and kidneys may through pressure cause complete atrophy of the parenchyma of the organ. Spontaneous fracture may follow the formation of bone cysts.

Only very general points can be given as to the diagnosis of cysts. As a rule they form circumscribed tumors, more or less movable, elastic, and fluctuating. Aspiration of the cyst contents and their chemical and microscopical examination often yield important aid in the differential diagnosis. This is especially true in the case of parasite and degeneration cysts. The location, manner of origin, character of cyst wall and lining, rate of growth, etc., are all points of diagnostic importance. The symptomatology of cysts in general is too large and complex to admit of definite generalizations, and only very general statements can be made in regard to their treatment. This is almost wholly along surgical lines, and consists either in the removal of the cyst as a whole or in its obliteration through aspiration and the excitation of reparative processes. *Aldred Scott Warthin.*

DACTYLITIS. See *Hands and Fingers, etc.*

DALTONISM. See *Color Sensations.*

DAMIANA.—The leaves of several Mexican and Central American species of Turnera, especially *T. diffusa* Willd., not all of them as yet determined, perhaps not even described. The drug contains a considerable percentage of volatile oil and resin, with some tannin and an amaroid. It is therefore an aromatic bitter. That it may have some special properties in this class appears not unlikely. The unprofessional and disgusting methods of its exploitation and use have naturally repelled the interest of investigators, so that it has not fared well at their hands. Its popular use as an aphrodisiac does not appear to be justified. The dose is 1 to 4 gm. (gr. xv.–lx.). *Henry H. Rusby.*

DAMMAR RESIN—(*Resina Dammara,* Ph. G.) Resins obtained from *Agathis Dammara* Rich. (*Dammara alba* Rumph) and *A. australis* (Lamb.) Salisb. (*D. orientalis* Lambert), Order, *Coniferæ;* and also from *Hopea micrantha* and *H. splendida;* Order, *Dipterocarpaceæ.*

The Agathis trees are large, straight-trunked, handsome firs, from whose branches an abundance of turpentine exudes, both spontaneously and upon incision. It dries rapidly, and hardens to dense, brittle, irregular tears or masses of resin, often of large size, the surface commonly warty or mammillose. The Hopeas are also tall large trees, and belong in an order which yields a number of other volatile and resinous products (Borneo camphor, Gurjun balsam, Indian copal, and so forth). The above trees are all natives of the East—the Moluccas, Java, Borneo, India, etc.

Dammar comes in fine, hard, transparent yellow, or nearly white, odorless tears, of irregular shape and size, but often large. It is brittle, breaking with a brilliant, conchoidal fracture, but softens slightly in the hand, and melts at about 120° C. Soluble in chloroform, ether, carbon disulphide, fats, and oils, but not entirely so in cold alcohol or in benzin. It is a compound of several resinous constituents—*damarylic acid* and its *hydrate, dammaryl* and *damaryl subhydrate* (Dulk: copied from Huseman).

Uses.—This resin is an ingredient of the German adhesive plaster—*Emplastrum adhæsivum* (Ph. G.), of which it comprises fifty of the six hundred and fifty parts—litharge plaster, yellow wax, and resin being the others. It is harder and perhaps less irritating than common resin, but not otherwise different. It is invaluable as a basis of varnishes, etc., for which it is principally used.

Several other species of both genera yield similar resins—*D. australis* is the source of the Kauri gum of New Zealand, also extensively used in varnishes. *W. P. Bolles.*

DANDELION.—*Taraxacum.* "The root of *Taraxacum officinale* Weber (fam. *Compositæ*) gathered in autumn" (U. S. P.). This well-known plant grows in the greatest profusion throughout most of the north temperate zone and is being increasingly cultivated as a food plant. Its reputation as a drug is of the most ancient character, but its professional use has steadily declined in the face of more accurate knowledge of drug action. The root is vertical, but rather crooked, mostly simple or with one or two branches parallel with and close to the parent, rarely reaching a foot in length and having the thickness of the finger. The drug more commonly has the dimensions of a lead pencil; it is brown, deeply wrinkled, light, soft and brittle. On fracture, the wood zone is seen to be small and bright-yellow, the bark whitish if carefully dried, otherwise dark. It contains numerous circles of laticiferous ducts, which, on paring the ends, glisten slightly, if the drug is of fine quality. The taste is distinctly bitter, and slightly sweetish, and a gummy consistence is appreciated upon chewing. The activity resides in the milky juice which fills these ducts. The official fluid extract is made from the dried root, but the Pharmacopœia directs that the fresh root shall be used in making the extract.

Composition.—The small amount of sugar, gum, resin, and wax-like substances, and the large amount of inulin are scarcely medicinal. The bitter principle is taraxacin. An alkaloid exists in minute amount.

Dandelion exerts no marked physiological action. It is somewhat laxative, hence depurative, and, because of a slightly increased elimination of bile, has been supposed to be a hepatic tonic. It does seem to possess slight alterative and tonic powers.

The dose of the fluid extract is 4 to 8 c.c. (fl. ʒ i.–ij.), of the extract 0.5 to 2 gm. (gr. viij.–xxx.). *Henry H. Rusby.*

DARIER'S DISEASE. See *Keratosis.*

DATES.—The fruit of the date palm, *Phœnix dactylifera* L. (fam. *Palmaceæ*). It is a fine large tree, indigenous to Africa and parts of Asia, but long cultivated in many varieties in the tropical parts of the old world. Like the cocoanut palm, it supplies a multitude of needs to millions of people in the warmer parts of the world; the young bud is eaten as a vegetable, the older leaves supply fibres for textile purposes, a sort of wine is made from its juice, the seeds are ground up for cattle or used as "coffee," and the fruits form an important article of food. Dried, or preserved in sugar, they are exported to all parts of the world as a sweetmeat and dessert. The larger variety is the Alexandrian, the smaller the Barbary date.

They contain *glucose,* fifty or sixty per cent.; gum, pectin, etc., ten per cent.; *coumarin,* a trace. Dates are simply an article of food and luxury, with only slight laxative properties. *W. P. Bolles.*

DATURA. See *Stramonium.*

DAVOS.—(Davos-Platz, Davos-Dörfli, and Wiesen.) Davos, the best-known and most frequented "high-altitude" winter station in Europe, is composed of two villages a short distance from each other—Davos-Platz and Davos-Dörfli. It is the former, Davos-Platz, which is always meant when Davos as a health resort is referred to.

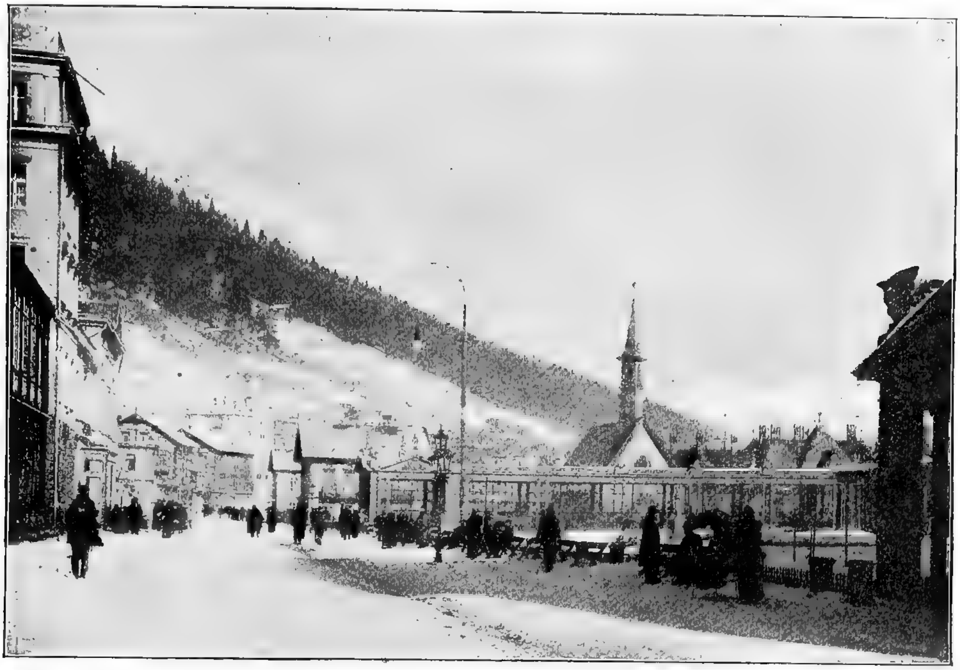

Fig. 1576.—Davos-Platz in the Winter Season

Davos first became known as a health resort for consumptives through Dr. Spengler, who was a physician there, and who communicated the fact of its immunity from phthisis to the German climatologist Meyer-Ahrens. Through the publications of the latter, Dr. Unger, a consumptive, with a friend likewise afflicted, went to Davos and was cured; and through the favorable reports and experience of Drs. Spengler and Unger the advantages of this climate for pulmonary tuberculosis began to be appreciated in Europe.

It was a radical departure from the existing ideas of a suitable climate for this disease, and it seemed a strange, not to say dangerous experiment for a consumptive to pass the winter in the snows of the Alpine Mountains. As the favorable reports of those who made the venture, however, became known, the fame of the place spread, and from eight in 1865 the number of consumptives who visited it increased yearly, until in 1890 they amounted to 1,511, of whom 89 were Americans; and now it is the most popular high-altitude resort upon the Continent, the English coming next to the Germans in numbers. It is called a "winter resort," the climate at that season being considered the most favorable, although Dr. Turban, who conducts a large sanatorium there, told the writer that the seasons should make no difference and that a patient should remain continuously until the cure was effected. The climate is characterized by a cold, pure, dry air of great diathermancy, much sunshine and but little wind, resembling closely that of Colorado, with the important difference, however, that the daily average of sunshine in the latter resort is much greater than at Davos. The snow covers the ground deeply during the winter (from three to five months), but it is a dry snow.

Davos is situated in the Canton des Grisons, Switzerland, in the upper Engadine, at an elevation of 5,115 feet above sea level. The valley of Davos is about fourteen miles long, and about half a mile wide, and runs from northeast to southwest. The mountains which shut in the valley rise from 2,000 to 3,000 feet above its bed. It is protected from the north and west winds; indeed, one of the most remarkable and characteristic features of the climate of this resort is its windlessness. It possesses all the attributes of an Alpine village—long winters; a mountain torrent, the Landwasser, traversing the valley; sparse vegetation; forests of fir and larch upon the mountain sides; high sun, and low, freezing, shade temperature. The soil is sandy and dry. The snow, which lies two or more feet deep during the winter, begins to melt about the middle of March, and patients leave about the first of April.

The average temperature for the year is 38° F., and for the seasons: Winter, 23° F.; spring, 35° F.; summer, 52° F.; autumn, 34° F.

The striking characteristic in the temperature, more or less common to all high-altitude resorts, is the great difference between that of the sun and that of the shade; in a moment one passes from winter to summer, or the reverse. Here is the comparison given by Richards in his article upon *Davos* in the previous edition of the Handbook, quoted from Weber.

Sun and Shade Temperatures at Davos, 1876–77 (Fahrenheit Scale).

	October.	November.	December.	January.	February.	March.	Average.
Mean maximum sun temperature	133.07°	106.12°	109.08°	108.30°	111.36°	122.32°	115.04°
Mean maximum shade temperature	60.40	36.63	39	36.07	34.55	36.46	40.51
Difference	72.67	69.49	70.08	72.23	76.81	85.86	74.53

Although the average winter temperature is so low (namely, 23° F.), yet in the sunshine one can sit in the open air with comfort or even be too warm. Moreover, in the shade and in the absence of sunshine, says Weber, low temperature produces very little discomfort at Davos as compared with that experienced in level countries, partly on account of the dryness of the air, partly also because there is very little wind in winter.

The highest or maximum temperature for the year is stated by Weber to be 75.2° F., and the lowest or minimum, −13° F. The average relative humidity is 77 per cent. for the year, 82 per cent. for winter, and 74 per cent. for spring and summer, as given by Waters, quoted by Solly. The absolute humidity, however, is very slight during the cold months, for it must be remembered that a high relative humidity at a low temperature would be a low one at a high temperature: for instance, the mean relative humidity at Davos for 1876 is given by Weber as 75.2 per cent., and the average yearly temperature is about 38° F. If now the mean temperature were assumed to be 98.4° F., the absolute humidity of the atmosphere remaining unchanged, the relative humidity would have been 11.1 per cent.

The annual rainfall and melted snowfall at Davos, as given by Waters from twenty-one years' observation, are 33.6 inches, and for the seasons: for winter, 6.1 inches; spring, 6.4 inches; summer, 11.9 inches; autumn, 9.2 inches. The average number of cloudless days for the season from October to March, inclusive, from four years' observation, compiled by Richards from Burney Yeo's tables, was 63.7; average number of fine but not cloudless days, 30.7; average number of cloudy days, 67.5; and average number of rainy or snowy days, 40. The average number of cloudless and fine days was 94.4 out of a possible 182, or about one-half. The average hourly velocity of the wind for the four seasons as given by Waters is: Winter, 1.6 miles; spring, 2.5 miles; summer, 3.4 miles; autumn, 2.4 miles. The prevailing direction of the wind is northeast.

Stillness of atmosphere, then, is another of the chief characteristics of the winter climate of Davos, although exceptions do occur and "bad winters," with many windy days, happen occasionally.

Owing to the fact that Davos is in a narrow valley shut in by high mountains, the length of the days is considerably shortened, especially in the winter. For instance, upon January 1st, the sun rises at Davos 11:03 A.M., and sets at 3 P.M., while at Denver, for comparison, it rises at 7:30 A.M., and sets at 4:37 P.M. In Colorado Springs the invalid's day in winter is given by Solly as seven hours long, while at Davos in the same season it is only about five hours long. The comparison of the amount of sunshine in Denver and Davos is given by Solly, as calculated from the weather-bureau reports and from Waters' tables, as follows:

Hours of Actual Sunshine (Monthly Means).

	Winter.	Spring.	Summer.	Autumn.	Year.
Denver	188	242	290	243	240
Davos-Platz	100	166	196	126	147

At Davos, for the months of January and February, 1890, there were 267 hours of sunshine, and in 1891, 285, or about four and a half to five hours per day.

It will be seen from the above consideration of the various climatic factors of Davos that the characteristic features are a pure, dry, rarefied air, almost complete absence of wind in the winter, and a large amount of sunshine, which in such an atmosphere has great penetrating power. The disadvantages are the snow-melting period in March or April, the shortness of the winter days, and the depressing influences of a monotonous existence in a narrow Alpine valley, covered with snow. When compared with a similar high-altitude climate in Colorado, for example Colorado Springs, the advantages of the latter are apparent: there is more sunshine, and the "invalid's day" is nearly two hours longer in winter. The fall of snow is "infrequent and scanty through the winter," and consequently there is no long period of snow melting in the spring. The vegetation is more abundant and varied, owing to the difference in latitude; and Colorado Springs and most of the other resorts are situated in broad, extended plateaus or open plains, giving one the feeling of freedom and exhilaration which comes from being able to look far away into the distance. There is, however, one grave disadvantage in many of the Colorado resorts, namely, the wind and dust. For a further comparison of the two regions the reader is referred to a valuable paper by Dr. Carl Ruedi (who resided both at Davos and at Denver), entitled "A Comparison of the Winter Health Resorts in the Alps with some Places in the Rocky Mountains of Colorado," Transactions of the American Climatological Association, vol. x., 1893-94.

The one disease for which a cure is sought in the Alpine altitudes is pulmonary tuberculosis, and to Davos comes the consumptive, not for relief but for the permanent arrest of his disease; consequently only such cases are suitable for such climatic treatment as offer a reasonable prospect of attaining this end. The following enumeration of suitable cases for the high-altitude treatment is given from the experience of various authorities: (1) Incipient cases; (2) hemorrhagic phthisis; (3) chronic pleurisy and unresolved pneumonia; (4) patients with more advanced diseases showing some consolidation but no excavation nor any serious constitutional disturbance: (5) cases of cavity, if not large and provided the disease is quiescent; (6) cases of imperfect expansion of the thorax.

The contraindications to the high altitude resorts are: (1) Advanced age; (2) the septic state, in which the disease is active and pyrexia constant; (3) double cavities with or without pyrexia; (4) cases in which there is great irritability of the nervous system: (5) diseases of the kidney, liver, or heart; (6) diabetes; (7) great loss of pulmonary tissue; (8) emphysema; (9) tuberculous laryngitis. In regard to the latter disease there is some difference of opinion. Solly, of Colorado Springs, for example, reports favorable results in its treatment in the high altitudes.

Symonds, in his charming book, "Our Life in the Swiss Highlands," thus narrates the "method of cure" at Davos; and although the account was written over twenty years ago it still remains essentially true at the present time. He says: "After a minute personal examination of the ordinary kind, your physician tells you to give up medicine, and to sit warmly clothed in the sun as long as it is shining, to eat as much as possible, to drink a fair quantity of Valtelline wine, and not to take any exercise. He comes at first to see you every day, and soon forms a more definite opinion of your capacity and constitution. Then, little by little, he allows you to walk; at first upon the level; next up-hill, until the daily walks begin to occupy from four to five hours. The one thing relied upon is air. To inhale the maximum quantity of the pure mountain air, and to imbibe the maximum quantity of the keen mountain sunlight, is the *sine qua non.*"

"When I came to Davos, for example," continues the same author, "at the beginning of August, I could not climb two pairs of stairs without the greatest discomfort. At the end of September I was able to walk one thousand feet up-hill without pain and without fear of hemorrhage. This progress was maintained throughout the winter; and when I left Davos in April the physician could confirm my own sensation that the lung, which had been seriously injured, was comparatively sound again, and that its wound had been healed."

With regard to the results obtained at Davos, Turban, who conducted a sanatorium there, published in 1899 an elaborate report of 408 cases treated by him, one-half of which were in the second stage of the disease, and one-quarter each in the first and third stages. Taking the three stages together, he discharged 66.1 per cent. "absolutely or relatively cured." Of this number 48 per cent. were found—by the examination made by a physician from one to seven years after their discharge from the sanatorium—to have remained absolutely or relatively cured. It must be borne in mind that these results were obtained by the combination of the sanatorium and high-altitude treatment.

Williams ("Aero-Therapeutics," 1894) gives the results in 247 of his own cases, whom he sent to Davos, Arosa, St. Moritz, and other high-altitude resorts. Of this number 161 were in the first stage and 86 in the second and third. A cure was effected in 40.89 per cent.; great improvement in 29.55 per cent., and improvement in 12.95 per cent.

In concluding his remarks upon the effects of the high-altitude treatment, Williams says that 75 per cent. of cases of phthisis generally are greatly improved, and in 43 per cent. the tuberculous process is more or less completely arrested. The beneficial influence of the climate is best shown, he thinks, in cases of tuberculous consolidation, in which improvement may be looked for in 87 per cent. and arrest in 57 per cent.

In a private letter received by the writer from Dr. Peters, of Davos, he says: "After eleven years' practice here in Davos, I can say that in 20 to 25 per cent. of cases a perfect cure, and in about 60 per cent. of all cases a great improvement, is obtained." "As to the treatment," he continues, "the principal thing is to spend as much time as possible outside in the pure, cold, dry, sunny air, lying, sitting, walking, skating, or tobogganing. One must sleep at least seven or eight hours, and make use of the cold shower bath and cold wet rubbings in the morning."

Davos-Platz is the chief centre for hotels and pensions and consequently for patients, although Davos-Dörfli in the winter receives the sun's rays two hours earlier, but at the same time loses them earlier.

The accommodations at Davos are abundant and excellent, consisting largely of extensive hotels, all of which are under general medical supervision. There are also several sanatoria, of which Dr. Turban's is the best known. Villas, pensions, boarding-schools for boys and girls, and other accompaniments of a populous and popular resort are to be found here. There are also good accommodations at Davos-Dörfli, which is connected with Davos-Platz by a tramway.

Davos has been accused of being overcrowded and consequently less salubrious, but for this charge there exists no ground whatever, says Williams. The drainage is excellent, and the water supply good. The food is abundant and well served. Davos is reached by rail from Paris, viâ Bâle and Landquart.

The attractions, for those who can safely indulge in them, are skating, tobogganing, sledging, and walking. The daily promenade upon the main street of the village is one of the features of the winter life at Davos. Here one sees the patients with faces bronzed by the sun, protecting themselves from its hot rays by parasols, when the temperature of the air is below zero.

Wiesen, which is about eleven miles below Davos-Platz in the same valley, is also a high-altitude health resort, with essentially the same climatic characteristics as Davos. It has an elevation of 4,757 feet, and instead of lying at the bottom of a valley, is situated about a thousand feet above the river bed, upon a terrace looking toward the South. Wiesen is said to have rather more sunshine than Davos; a slightly higher and more equable winter temperature, and a winter season which is several weeks or a month shorter than the winter proper at Davos. There is also an early "clearance of snow," and the snow-melting is more rapid than at Davos. Moreover, there is no morning or evening mist at Wiesen, according to Dr. Wise, in fine weather, whereas at Davos, "a perceptible mist generally covers the valley each morning." There are several good hotels at Wiesen, and it would appear to be fully as favorable as a climatic high-altitude station as Davos. As yet it has not been utilized by any large number of consumptives.

The writer has personally visited the resorts above described, but in the summer when the majority of patients were away. He can, however, testify to the remarkable invigorating quality of the air and the intensity of the sunshine. The sensation produced by the deliciously fine, dry, cool air and the warm sunshine is quite indescribable. One feels as if he could take an unlimited amount of exercise without the least sensation of weariness. The approach to Davos, either by the Landwasser route or viâ Landquart, is one of great scenic attraction.

Edward O. Otis.

DEAD, DISPOSAL OF THE.—History teaches that at all times and in every country man has manifested in different ways his respect, his reverence for the memory of those he had loved in life. At all ages has the cult of the dead been consecrated by religion and by law. This universal reverence for the dead has given rise to funerary ceremonies which greatly vary according to the times and degrees of civilization of the different nations. In all these various ceremonies, however, whether the result of faith or of instinct, we can trace evidence of a general belief in future life.

Three methods have chiefly been employed for the disposal of the dead: First, Burial; second, embalming or mummification, and third, incineration or cremation.

In ancient Egypt, funeral ceremonies were attended with great pomp, amidst grand demonstrations of sorrow. The most interesting ceremony was that called "The Judgment of the Dead." Forty judges, selected among the oldest and most respectable citizens, examined minutely the acts and conduct of the dead person; if his life was pure, the body was allowed to be transported to the *Necropolis*, otherwise it was thrown into a common "fossa" (trench). Kings themselves were submitted to this "Judgment of the Dead."

The old Hebrews buried in the ground the common people and embalmed preciously the bodies of prominent persons before burying them. According to some passage of the Bible, these bodies were also at times cremated.

The old Persians, in common with most Oriental people, looked upon a cadaver as being impure, and as they adored the elements, they could not contaminate them, either by burning the dead body, by burying it into the ground or by throwing it into water. Each town in Persia possessed beyond its walls two high stone towers, one of white stone and the other of black stone. The dead were judged by the priests, who ordered the good to the white tower and the bad to the black tower. A large number of buzzards were kept for the purpose of devouring the dead bodies and thereby preventing infection. Death was not considered as a misfortune; lamentation and crying were forbidden by law. The funeral ceremonies ended generally in a great banquet.

In ancient Greece, funeral ceremonies were attended with great pomp and religiously practised, for it was believed that without them the souls of the dead could not enter the Elysian Fields. As soon as a person was dead, a piece of money, called δανάκη, with which to pay the passage to eternity, was put in his mouth. The body was washed and rubbed with perfumed oil and the head crowned with flowers; the body was robed in the finest white garment; it was then exposed at the main door of the house; by the side of the bier were placed precious vases that were buried with the dead, and near the body were also placed a cake made with honey and a vase full of water, in which the friends and assistants could purify their hands. Relatives surrounded the death-bed, all in tears and deep sorrow, the women tearing their clothes and pulling out their hair. The body was either buried or cremated, for both modes of sepulture existed simultaneously among the Greeks. Socrates ordered his body to be burnt, and Plutarch speaks of the burning of the bodies of Timoleon and others. In olden times, together with the dead body were also burnt, in some instances, animals, as well as slaves and captives. Thus Achilles, at the incineration of his friend Patrocles, ordered the burning of a large number of sheep, beef, horses, and dogs, as well as twelve Trojan prisoners. Bodies that were not burnt were buried in coffins of varied shapes, and mostly made of earthenware. Interments took place outside of the city walls, as burials in the centre of the town were considered a danger to the living. Mortuary banquets were the prevailing custom, and monuments of architectural beauty were often erected over the site of burial. At Athens and at Sparta, deep mourning was observed by parents and relatives; they did not show themselves in public and had their hair cut. In those cities bodies of criminals were thrown away in special excavations.

The Romans followed most of the customs of the Greeks in their funerary ceremonies, such as anointing the body with perfumed oil, placing a piece of money in its mouth, robing the dead in its finest garments, etc. Couches or litters on which the body was carried by the nearest relatives were made of ivory, covered with gold and purple. Julius Cæsar's body was carried by the magistrates and that of Augustus by senators. After they had passed through the Forum, a halt was made at the rostrum where funerary discourses were delivered. From the Forum the body was carried to the place of sepulture or incineration. This place was always outside of the town walls. During the first centuries the Romans buried their dead. Yet we see by the law of the Twelve Tables that the custom of burning dead bodies had become general during the last years of the republic. Under the empire it gradually grew less and had almost entirely been put aside during the fourth century. As in Greece, the *pyra*, or funeral pile, on which was placed the cadaver, was sprinkled with perfumes and at times richly ornamented. Prisoners and slaves were at times sacrificed on the pile. Banquets and gladiators' combats were often made part of the funeral ceremonies. We read that at the funeral of P. Licinus Crassus, who had been sovereign pontiff, meat was distributed to the people, there were one hundred and twenty gladiators in the arena and funeral rejoicings lasted three days, after which there was a large public banquet in the Forum.

Burial.—As has been said, the ancient Hebrews, Greeks, and Romans ordered their burying grounds to be located outside of the city walls, in the fear of contamination to the living. The first Christian cemeteries that were consecrated in the beginning of the third century were also located outside of the town; later on, whether from a sentiment of piety or of vanity, many of the faithful sought the honor of being buried in the interior of churches. This custom prevailed more or less extensively in different countries, and has not yet been entirely discontinued in spite of all the efforts of sanitarians to abolish it. Bishops and high functionaries are still buried in churches.

There are but few remaining cemeteries that were built during the Middle Ages; the most remarkable of these is the well-known Campo Santo of Pisa, Italy, built in 1218.

In order to diminish as much as possible the dangers of earth and vault burials, all civilized communities have adopted stringent police regulations governing cemeteries. These should by all means be located outside of towns and thickly settled localities. They should be planted with trees, with due regard to ventilation; each fossa, or trench, should have a depth of from four to six feet, and there should be at least three feet distance between the trenches. Five years should have elapsed before permitting the opening of the tomb for a new burial.

Decomposition of a body is more or less rapid according to climate, conditions of the soil, the material of the coffin, the clothing or coverings of the body, etc. Low, damp ground, saturated with water, hastens decay. Embalming, a metallic coffin, retards it. Rapid decomposition should be favored by all possible means. Burial in the ground is preferable to above ground, intermural, or brick-vault burial. It facilitates decomposition of the tissues and absorption by the earth of obnoxious gases and emanations. With all these precautions, ground burial, especially in populous towns and districts, remains a dangerous and unsanitary practice. The earth soon becomes saturated with products of decomposition; these, no longer absorbed, escape through the air, permeate the soil and water and may carry infection to great distances. Fatal epidemics are known to have occurred from such general contamination.

Embalming.—The object of embalming a dead body is to preserve it from decomposition and to keep it for a certain period of time. Nearly all nations of antiquity were in the habit of embalming. The Egyptians, above all others, were masters of that art, as we see by their mummies, which date back for series of centuries.

Their system consisted in, first, removing all the viscera from their cavities and dissolving them in caustic liquids; second, submitting the body for a space of seventy days to the action of natrum or carbonate of soda, to remove all fatty substances; and third, obtaining desiccation of the body by exposing it to the air or to the heat of an oven. While undergoing this desiccation, the body was varnished externally and filled internally with odoriferous substances destined to remove insects, or it was plunged in melted bitumen or wax, which permeated every part. Finally, innumerable bandages dipped in gums were applied with the greatest care over all parts of the body, thus excluding air and humidity. This ingenious proceeding was undoubtedly greatly aided by the permanent high temperature and dryness of their mortuary chambers, where the mummies were kept. Mummies, in a remarkable state of preservation, dating back more than three thousand years, have been found in the necropolises of Upper Egypt.

During the Middle Ages, and even later, the processes of embalming the bodies of kings and illustrious men were more or less imitated from the Egyptian methods. In modern times, thanks to the remarkable progress of chemistry, substances have been found capable of preventing decomposition. Numerous chemicals have been used for that purpose. Among them, bichloride of mercury, acetic acid, sulphurous acid, sulphate of iron, chloride of zinc, arsenic, etc. Bichloride of mercury and arsenious acid are perhaps the most efficient, but may be objectionable from a medico-legal point of view. Nowadays, chloride of zinc, injected in the popliteal artery in both directions, and the new germicide, formaldehyde, are the agents preferred by embalmers.

Professor Garini, of Italy, is the discoverer of a process of embalming, which he has so far kept secret, by which anatomical preparations and whole bodies present the hardness of stone and the appearance of wax and can be preserved indefinitely. It is a sort of petrification. The body of the great patriot Mazzini is so preserved in Genoa.

Under certain natural conditions dead bodies are known to have been kept intact, without putrefaction, mummified, for an indefinite period of time. We all know that congelation prevents decomposition. In Siberia there have been found fossil elephants, buried in ice, whose skin and flesh had not suffered the slightest alteration. Extreme heat seems to produce the same effect. Humboldt has found natural mummies in Mexico. In Peru, travellers have discovered in a certain locality possessing a perfectly dry soil and exposed to a burning atmosphere, mummified dead bodies of Spaniards and Peruvians that had been lying on the ground for centuries. There are certain soils, also, in which bodies become mummified; for instance, that of the cemetery of St. Nicholas, in Toulouse, France. Under certain favorable conditions a constant current of cold, pure air, in a high altitude, will produce the same results. In a church near Bordeaux there can be seen, under the tower, a cave containing one hundred naturally mummified bodies. At the Sacra of San Michele, in Piedmont, I have seen myself a similar cave with a number of mummies of Monks in their robes and looking perfectly natural, some dating back several centuries, others more recent.

Cremation.—The subject of cremation is one of very great importance, and it is rather surprising that it has so far received but little attention from our local sanitarians. While great efforts are being made in Europe and in a few of our States to introduce or generalize the practice of cremation, there generally exists a strong opposition to this most essential sanitary measure. Our people are prejudiced against this beneficial hygienic reform, the great advantages of which are, perhaps, not generally known or sufficiently appreciated. But if the introduction of cremation should meet with some opposition in our midst, we can easily be consoled with the thought that such has been the case, at all times and in every country, with every innovation, however useful or necessary. All important discoveries, all new ideas of science have had their enemies. Time alone, with the assistance of reason, can uproot prejudices and foster new ideas, heretofore condemned or rejected simply because they were not well understood and studied.

In this article I shall endeavor to show the dangers of earth and vault burials; to explain what the system of cremation really is; in what its hygienic advantages consist; and to demonstrate its superiority over all other methods of final disposition of the human body. I hope that the historical considerations, and the well-observed facts upon which I shall dwell will convince every intelligent person of the absolute necessity of a complete reform in our methods of burial, especially in cities and thickly populated districts.

The question of how to dispose of the dead with the least danger to the living has at all times absorbed the attention of sanitarians and occupied the public mind. One is greatly surprised, in looking over the literature of the subject, to find that as far back as the year 1539 the question of the different methods of sepulture was discussed and gave rise to the publication of several remarkable works, among which we shall mention those of Gyraldus Ferrarensis, of Ferrara, Italy, "De Sepulchris et vario Sepellendi ritu Libellus"; of Claude Guichard, published at Lyons, in 1581, entitled "Funérailles et Diverses Manières d'ensevelir des Grecs, Romains, et autres nations tant anciennes que modernes." In 1636 there was published in Holland a letter (epistola) in which the custom of burying in temples was severely condemned. In 1658, Thomas Brown published, in London, a memoir on "Hydriotophia," or urn burial. In 1729, Groenen wrote his "Dissertatio Inauguralis de Noxis ex Sepultura in Cœmeteris ex Urbibus tollendi," Frankfort; and a few years later appeared another thesis by John Godfrey, "De Sepulchrorum salubri translatione extra urbem" (Hall); and a "Mémoire sur les Dangers des Inhumations dans les Églises," by Huguenot, from Montpellier (1747); and one year later Panenot wrote "De Sepultura in Urbe et Templis prohibenda," published in Utrecht. From this time were published every year books and memoirs of more or less importance on the dangers of burial in churches and cities.

In 1790, Thouret et de Fourcroy published their report, "Sur les Exhumations du Cimetière et de l'Eglise des Innocents" (*Bulletin de la Société Royale de Médecine, et Annales de Chimie*, 1790). This report was translated into German, in Crell's *Chemik Annalen*, in 1792. During the last years of the eighteenth century and the first years of the nineteenth, many publications on the dangers of cemeteries, and the necessity of their removal from large centres, came to light in Germany, among which those of Wurzer, Trommsdorf, Fluegge, Reinhardt, Joannis Petrus Frank, and others. One of the greatest of German poets, Goethe, was a strong partisan of cremation. In 1830 Orfila published his "Mémoire sur les Exhumations Juridiques," and in 1839, another memoir, "Sur les terrains des Cimetières, sur l'Arsenic qu'ils peuvent contenir, et sur les conséquences médico-légales que l'on doit tirer de l'existence possible d'un composé arsénical dans ces terrains" (*Annales d'Hygiène*). Many cases of poisoning by gases, from tombs or from the soil of cemeteries, were published about that time. In 1843, Chadwick, of London, made a report "On the results of a special inquiry into the practice of interment in towns." In 1849, Grimm, Moleschott and others, in Germany, began scientifically to discuss and advocate cremation as actually practised. In 1852, Ambroise Tardieu wrote his "Voiries et Cimetières." In 1855 was published a work on "Cremation in Japan," by Sagholin. That same year, or the year following, appeared several works on cremation, by Cobb, of London, Colletti, of Padua, and Loude, of Paris; since which time the subject of cremation has been constantly agitated and discussed, all over the world, in medical and scientific publications.

Connected with this subject, there were frequently published, in different countries, papers and reports on the dangers of well and spring waters in the environs of graveyards. See *Bull. de l'Acad. de Médecine*, and *Annales d'Hygiène*, 1869, 1870, and 1871.

Within the last twenty years an immense number of books, memoirs, and papers on the subject of cremation have been published in every country of Europe, and more recently in the United States. Without, perhaps, a single exception, the habitual method of burial, especially in cities and thickly peopled countries, has received the universal condemnation of science all over the world, and in its place cremation, or rather incineration, has been everywhere recommended as a perfectly safe, rational, and unobjectionable practice, one which would destroy powerful causes of disease and greatly promote the public health. Under the empire, thousands of French soldiers, who had perished during the disastrous retreat from Moscow, were burned by the Russians; and in 1814, after the battles around Paris, more than four thousand dead bodies were *incinerated* at Montfauçon, during the space of fourteen days, to prevent infection. . . . The same was done after the battle of Sedan, in 1870. Since 1876 cremation has been introduced in almost every country in Europe and in America. Italy is perhaps the country in which this great sanitary reform has been carried forward with most energy and success; this result being due in a great measure to the efforts of Castiglioni, Gorini, Amati, Dell'Acqua, Mantegazzi, Polli, de Cristoforis, Pini, and others. Let us here mention, among the conspicuous men who have taken a leading part in the diffusion of cremation, Professor Brunetti, of Padua, Professor Reclam, of Leipsic, Dr. Siemens, of Berlin, and Sir Henry Thompson, of London, who wrote such remarkable articles in the *Contemporary Review* in 1874. Among the partisans of cremation in our own country we should not neglect to name Henry Laurens, a military attaché and friend of General Washington, the first person whose remains were formally cremated on this side of the Atlantic; Henry Barry, of South Carolina, whose remains were burned in his own garden, according to his instructions; Rev. Dr. Beugless, of Brooklyn, whose writings have so greatly contributed to the diffusion of the knowledge and advantages of cremation among us; and last, but not least, Dr. Julius T. Le Moyne, of Washington, Pa., who, besides much writing and speaking in favor of cremation, had erected at his own expense a crematorium, in which his remains were cremated, and which still stands, an honor to his zeal and earnestness in the cause of cremation.

Within the last few years cremation has received the highest and most valuable indorsement from one of America's greatest surgeons and scientists, Prof. Samuel D. Gross, of Philadelphia, whose body was, at his own request, incinerated in Dr. Le Moyne's crematorium. Numerous medical societies have since indorsed cremation as an essential sanitary measure. The American Medical Association has given that practice its official sanction and approval.

We see that, at all times and in every country, the custom of earth burial has been strongly condemned by the most enlightened men of the time. We notice that particular objections have have been, as far back as three centuries ago, to burials in churches and in cities. The dangers from such practices were clearly demonstrated in 1636, and even at that remote period strong efforts were made by physicians and savants to have cemeteries built outside of city limits. Such unanimity of opinion, in all countries and at all times, would by itself be sufficient to establish beyond a doubt the real and positive danger of earth and intra-mural burials. But still better to convince and satisfy the most incredulous, we beg leave to give here a few striking illustrations of said dangers.

It was Sir Henry Thompson who said, in 1874: "No dead body is ever placed in the soil without polluting the earth, the air, and the water above and around it." This saying has been confirmed by men of science in every country of Europe and America; and nowadays the fact of the pollution of air, soil, and water by decomposing bodies is as well ascertained and recognized as are the poisonous qualities of strychnine and arsenic, or the froth of a rabid dog.

It is well known that grave-diggers, who are generally of strong constitutions, very seldom live to old age. "In the Middle Ages, when burial in churches was common, they fell victims by hundreds to their horrible duties," says Wagner-Ercolani, who observes that even now "they are mostly pale of face and seldom healthy." Instances of the sudden death of grave-diggers by foul-air poisoning in the bottom of vaults were very numerous in the past and are still of frequent occurrence. A few years ago three grave-diggers in Paris died suddenly while lowering some coffins in a deep vault. Fetid emanations from decomposing bodies are mortal if breathed in a concentrated state, and when diluted in the atmosphere diminish the vital powers and produce low forms of fever, which are often fatal. Dr. Copeland relates that a gentleman of his acquaintance was poisoned by a rush of foul air from the grated openings at the side of the church steps; he was seized with a malignant fever which he communicated to his wife. There are well-authenticated cases of sextons being infected while shaking and cleaning the mattings of church floors, the mats being saturated with the poison of the vaults (Williams on "Cremation").

We may here mention the fact that the experiments of Drs. Koch, Evart, and Carpenter have shown that the blood of animals dying of splenic fever may be dried and kept for years, and pulverized into dust, and yet the disease germs survive with power to produce infection. We all know of the plague of Modena, breaking out in 1828, in consequence of excavations made in the ground where, three hundred years before, victims of the plague had been buried. A similar fact occurred a few years ago in Derbyshire, England, and the terrible violence of the cholera in London, in 1854, was charged to the upturning of the soil wherein the plague-stricken of 1665 were buried.

In 1843, the population of Minchinhampton, England, was nearly decimated by a disease manifestly caused by using as fertilizer for their gardens the rich soil of an abandoned graveyard. In 1823, an outbreak of the plague in Egypt was confidently traced to the reopening of a disused graveyard at Kelioab, fourteen miles from Cairo. A few years ago, the villages of Ritondello and Bollita, in Italy, were decimated by a terrible epidemic, the origin of which was unmistakably traced to the cemeteries. More recently, the monumental cemetery at Milan, situated on a hill to the north of the city, was proved to be the cause of a fatal epidemic that prevailed in parts of the city, the wells being the channel of communication and infection (Williams).

The investigation and experiments of Professor Pettenkofer, of Munich, have proved conclusively the manner in which graveyards exert their poisonous influence through air and water—*Grundluft* and *Grundwasser*.

The danger of contamination of wells, fountains, and running water in and around burial-grounds is well known. This contamination sometimes extends to quite a distance, as we have seen, and is a source of far greater danger than is generally supposed. These waters present a sparkling and seductive appearance—due to a large proportion of nitrates and nitrites—which make them still more dangerous. "It is a well-ascertained fact," says the London *Lancet*, "that the surest carrier and the most deadly, fruitful aider of zymotic contagion is this brilliant, enticing-looking water charged with the products of decomposition." There are many examples of transmission of disease, such as typhoid fever, dysentery, by water apparently pure and attractive, running in or around burial-grounds, or in the vicinity of places where the *excreta* from those diseases had been simply deposited.

In the strata of air lying in a prolonged calm above a cemetery, Professor Selmi, of Bologna, discovered an organic corpuscle (the septo-pneuma) which poisons the atmosphere to the detriment of the living economy. This substance, says Dr. Pietra Santa, which it is easy to collect and isolate, if placed in a solution of glucose, produces the phenomena of putrid fermentation, and gives birth to a considerable quantity of bacteria similar to those which are manifested in butyric fermentation. A few drops of this solution, injected under the skin of an animal, bring on the symptoms of typhic infection, and death supervenes on the third day. Infiltrated into water courses, this substance has doubtless carried infection and death into important towns.

It was Professor Selmi who discovered those deadly poisons he called *ptomaïns* or *alkaloidi cadaverici*. By protracted experiment, he showed, and his results have been confirmed by other investigators, that the common constituents of the human body, as the brain, the blood, fibrin, etc., perfectly innocuous in health, are rapidly converted by decomposition, under certain conditions of heat and moisture, into new alkaloids, analogous to those of plants, and equally virulent. He even showed that death does not always precede the change, but when the disease is one that induces internal decomposition of the plasmatical or histological elements, the transformation into *ptomaïns* may take place while the patient is still alive, or immediately after death, before any indication of external putrefaction becomes apparent.

A few years ago, in a celebrated trial which took place in Italy, in which a party was accused of poisoning by strychnine, this eminent chemist saved the prisoner from the gallows by proving, to the satisfaction of the tribunal, that the poison found in the dead body was simply an alkaloid formed in the body after death, by the natural process of putrefaction.

Dr. Domingo Freire, of Rio Janeiro, asserts that, while investigating the causes of a recent epidemic of yellow fever, he came upon the dreadful fact that the soil of the cemeteries in which the victims of the outbreak were buried was positively alive with microbian organisms, exactly identical with those found in the vomitings and blood of those who had died of yellow fever in the hospital. This characteristic parasite, says Dr. Freire, permeates the soil of cemeteries, even to the very surface. From a foot underground he gathered a sample of the earth overlying the remains of a person who had been buried about a year before; and though it showed nothing remarkable in appearance or smell, under the microscope it proved to be thickly charged with those yellow-fever germs. The cemeteries, therefore, Dr. Freire pronounces "nurseries of yellow fever, and perennial foci of the disease." It may be proper to mention here that since our first edition, Dr. Sanarelli, of Montevideo, seems to have positively discovered the micro-organism of yellow fever. His claim, however, that he has succeeded, by cultivating and attenuating said micro-organism, in obtaining an antitoxin that is both *curative* and *prophylactic*, has not yet been confirmed.

The above-given facts, as well as the facts relating to the breaking out of the plague in Modena in 1828, and of cholera in London in 1854, from the opening of trenches in graveyards in which, three or four hundred years before, plague- or cholera-stricken victims had been buried in the ground, and those that have been observed in New Orleans during the cholera epidemic of 1832, and in New York in 1806, at the time the Potter's Field was abolished and converted into a public square (Washington Square), all go to demonstrate most positively that soils once saturated with products of decomposition may retain for an indefinite period their infective properties, and continue for generations to be a source of danger. This danger exists at all times, but during epidemics becomes threatening indeed. In fact, we have seen that the bodies of those who die of contagious or infectious diseases are a source of alarming danger, not only during life, but long after they have been buried according to prevailing custom.

Does not the germ theory of disease, the doctrine nowadays generally accepted by the scientific world, explain in a perfectly satisfactory manner this pollution of soil, air, and water by decomposing bodies? Darwin, Pasteur, Koch, and others have already shown that the immediate essential cause of most contagious and infectious diseases is a living animalcule, or microbe, capable of reproducing itself *ad infinitum.*

These germs are possessed of a vitality, of a power of reproduction and resistance, which is really wonderful. It seems that the lower in the animal scale is an organism, the more numerous and prolific are its species, the more clinging its vitality. We have an additional proof of this in the particular, and at one time mysterious, mode of transmission of charbon (anthrax), first observed by the illustrious Pasteur. A sheep which had died of charbon was buried at the depth of twenty feet in the ground, in a field which, for ten or twelve years after, ceased to be used as a pasture ground. After that length of time some healthy sheep were pastured in that field; soon after, three sheep were taken sick and died of charbon, at a time when the disease did not exist in that locality or the environs. Upon diligent investigation it was found that the animal affected with charbon, and which had been buried twenty feet deep ten years before, was the cause of this new breaking out of the disease. Pasteur demonstrated that the germs of the disease were brought to the surface by earth worms.

Are not all these facts positively conclusive? Can any one doubt the infective qualities of soil saturated with the poisonous germs of disease? In the light of the late researches and discoveries of science, it is not difficult to understand how cemeteries may continue for centuries to be the *nidus* and *habitat* of the living microbes of virulent diseases.

From the very moment the vital spark abandons an organized living body, be it man or the lowest animal, putrefaction begins its slow and loathsome process; it gradually passes through the different phases of putrid decomposition, too horrible to behold or even to describe, until all the constituting elements of the decomposing body are finally set free by a slow and dangerous process of combustion. This process has been known to last, according to circumstances—especially according to the nature of the soil in which it takes place—ten, twenty, fifty, and even hundreds of years! While this slow and horrible process of decomposition is going on, every particle of matter around it is being saturated and infected with these germs of disease and death. This pollution of air, soil, and water takes place more readily, and gives rise to special dangers, in certain soils and climates;—for instance, in lower Louisiana, where the atmosphere and soil are saturated with dampness, subsoil water is found at only a few inches from the surface, and the land is of such a nature as to absorb and retain all sorts of offensive and poisonous matter. With all these unfavorable conditions of climate and soil, they have adopted, in New Orleans, a method of disposing of the dead which is quite peculiar to that locality. With a few exceptions the dead are not buried in the ground, as is generally the case all over are the world, but deposited in tombs or ovens above ground, generally badly constructed and exposed to the alternate influences of a burning sun and excessive moisture. No disinfectants are used either in the coffins or in the vaults, and, to make matters worse, most of the cemeteries are overfilled and located in the very heart of the city. This practice constitutes one of the worst unsanitary features of that city, where cremation is more needed than anywhere else.

We have seen that the ordinary mode of inhumation presents a double danger: first, the contamination of earth, air, and water, which may extend to quite a distance; second, the reproduction of *special* contagious and infectious diseases by germs which are buried with the human body, but not destroyed. How are we to destroy these disease germs? What is the remedy? There is but one. That remedy is cremation or incineration. Cremation alone will put an end to the pollution of earth, air, and water. It applies not only to the dead human body, but to animals, to garbage, to everything which is offensive or dangerous to health. Cremation alone can completely annihilate the living organisms or germs of contagious and infectious diseases. The ashes from the incinerated bodies of victims of smallpox, plague, yellow fever, or cholera are as pure, as clean, as innocent as those of the most precious woods or metals.

We should by all means prefer cremation to the Potter's Field and all its horrors. The relics of the dissecting-room, of the dead-house, etc., should be properly cremated. In epidemics of a contagious or infectious character, the crematory flame should be made, by law, the great purifier. The garbage of cities should be cremated. It is the safest and cheapest manner of disposing of it.

It is evident that these germs of disease are not destroyed by being simply deposited in any particular locality, however remote from large centres. The stopping of intramural interments only partially remedies the evil. It does not solve the problem; it only adjourns the question. The legal obligation to establish cemeteries beyond certain limits, as in the case of the new cemetery of Paris, at Marly-sur-Oise, sixteen miles from the capital, is simply planting the seeds of disease and death a little farther off. The cemetery will always be a focus from which death radiates. One shudders at the thought that in all large cities, or in their immediate vicinity, there are constantly to be found, in a state of complete putrefaction, as many as forty and fifty thousand corpses.

Sanitary reasons should alone influence and determine the scientist and the physician in all questions of science, especially in all questions which concern the public health. Having said this much in favor of cremation, from a sanitary point of view, I might here put an end to this article by giving a short description of the most approved processes of incineration. But the subject would be incomplete without a few considerations on the religious, sentimental, and utilitarian aspects of the question, more especially as the greatest objections to the generalization of cremation come from the want of proper understanding of these questions.

For my part, I do not see why the religious question should enter into the subject of cremation. Religion has nothing whatever to do with this great sanitary reform, not more than it has in questions of drainage, sewerage, water-closets, or any other sanitary measure.

Cremation is nothing else but a very simple method of reducing the human body to its constituent elements without injurious consequences to the living. It is in strict conformity with the laws of nature, and merely accomplishes in a few minutes that which putrefaction would take months and years to accomplish. It is nature's remedy, *combustion*, facilitated, hastened, and purified, and rendered innocuous by the application of the laws of modern science. Why should it be called a barbarous custom, a relic of paganism? Was not inhumation practised by antiquity as well as cremation? Yet the custom of burying the dead, which we owe to antiquity as well as many other customs, such as baths, festivals, etc., has never been called a barbarous or pagan custom. And how can ignorance and fanaticism base their objections to the system of cremation on the religious idea of resurrection? Does an omnipotent God need the assistance of man to accomplish his great work? Is the void of the tomb more favorable to resurrection than are the ashes of the urn? That power which can recall to life every part and parcel of the human body, whether devoured by ferocious beasts or burnt at the stake like the martyrs and saints thousands of years ago or dissolved in the waters of the seas or which have turned to clay on many a battlefield, can certainly resuscitate the ashes of the funereal urn in the hands of friends.

In all countries where cremation has been adopted it is only after all religious rites and church ceremonies have been performed that the corpse is taken to the crematorium. The process of cremation is no more incompatible with the idea of religious services to the dead than is our present method of inhumation in a tomb or in the bowels of the earth.

The religious rites could be performed in church or at the crematorium in a room especially consecrated to that purpose.

I am happy to notice that of late the opposition to cremation, on religious considerations, has considerably diminished. Some of its most enthusiastic advocates in our country are either clergymen or zealous members of the church. In Italy the opposition of the Catholic clergy has apparently entirely ceased, and in Rome itself a splendid crematorium has been built, and cremation is steadily on the increase—forty bodies have been cremated there during the last four months. By degrees, all objections based on considerations of a religious character will disappear, and I do not believe that at the present day an intelligent and enlightened member of the clergy, of whatsoever sect or creed, could be found honestly to oppose cremation on religious grounds. Ignorant and bigoted persons may, willingly or not, confound the two questions; not the intelligent and philanthropic.

In this utilitarian age the question of economy is not to be despised. Statistics show that the sums annually expended in the United States as funeral expenses exceed the value of the annual produce of all our gold and silver mines, and equal the amount of all the failures of our business houses of the country (Beugless). A decent burial costs not less than $100, exclusive of the price of the tomb or vault. How many families are daily impoverished by the excessive cost of interment incurred through false pride! How often expensive burials are given to those who in their lifetime lacked all the necessaries of life! The whole cost of cremation would not reach one-twentieth part of the price of an ordinary tomb and interment. As practised at present in Milan, the cost for cremating one body is only eight francs! But, from a general point of view, the great economy would be that of land and space occupied. The practice of cremation would eventually restore to the state or community vast amounts of valuable land now used as graveyards, which are lost to agriculture and industry. Under the present general system of interment the dead are gradually crowding out the living. Take, for instance, the city of London, with an annual death rate of only twenty-one per thousand; the number of deaths is about eighty-one thousand per annum. Have you calculated how much space is required for the annual burial of eighty-one thousand persons? At the limited rate of two feet by six per person, or twelve square feet per each grave, you can bury three thousand six hundred and thirty bodies to the acre; but this allows nothing for walks, roads, gardens, monuments, etc. On this crowded theory of three thousand six hundred and thirty graves to the acre, London's annual deaths will fill twenty-two and one-third acres. Of course, it practically requires four times as much space. Cremationists do not advocate the abolition of cemeteries now existing, but they claim that, through the process of cremation, cemeteries would cease to be nuisances and would become amply sufficient for all time to come. On the smallest lot of ground, an edifice in the shape of a columbarium, divided into compartments, would serve the same family for ages. It has been calculated that six millions of urns, each containing the ashes of one person, and placed in separate compartments, would not require twenty acres of land, including the flower beds, walks, etc. Greenwood Cemetery alone could receive no less than twenty million urns. Owners of lots in graveyards would not be slow to perceive the increased value of their property, since the space for an ordinary vault, twenty by twenty feet, could receive four hundred urns. The sale of a compartment or vault would yield greater profit than the sale of a whole lot could possibly now give, and cemeteries would never be full. Each and every church or temple could accommodate four thousand urns containing the ashes of as many persons, without any resulting injury, thus serving a religious purpose while being a legitimate source of income to the church (Beugless).

The generalization of cremation would render impossible the desecration of tombs and the theft of dead bodies, examples of which have been quite frequent of late in our country. Be it sufficient to recall the theft of the body of the late millionaire, A. T. Stewart, of New York, and the attempts made to steal the bodies of Presidents Lincoln and Garfield, without mentioning the many instances of body-snatching for the purpose of dissection, etc.

With that system in vogue the danger of being buried alive will no longer prey on our imagination. This danger is not chimerical. In a recent work published in Italy on the dangers of premature inhumation, no less than sixty-five well-authenticated cases of burial of living persons are related.

Again, cremation offers the advantage, the consolation, of being able to preserve and transport the ashes of those whom we have loved. Many of us will heartily join Rev. Burke Lambert, of England, in his opinion when he said, recently: "I have lost three very dear kinsfolk in remote quarters of the earth, and I would give everything I could command if I could receive their ashes and keep them by me in a vase."

Why should not the purification of human remains be intrusted to this rapid method, which frees the sepulchre of its horrible mysteries, and which in its comeliness retains a certain degree of poetry? For "Cremation," says Professor Gross, "is truly a beautiful method of disposing of the dead."

The process of cremation does not consist, as is erroneously believed, in the *burning* of a corpse. It is a mere incineration or reduction of the body to ashes by means of dry heat, reaching as high as 1,500° and 2,000° F. Neither fire nor flames ever come in contact with the corpse. All the smoke and volatile substances resulting from combustion pass through a heated absorbing retort and are immediately destroyed. The process has been described by ocular witnesses to be as follows: The body is borne into the chapel and placed on a catafalque, which stands in front of the altar. The section of the chapel floor upon which the body rests constitutes the floor of a lift or elevator. As the funeral service proceeds, the elevator invisibly and noiselessly descends, bearing the body to the basement in front of the incinerator, which by means of superheated air has been raised to a white heat within, at a temperature of about 1,500° F. As the door of the incinerator is opened to receive the body, the inrushing cold air causes the temperature to fall a little, and gives to the interior a beautiful rose tinge. The corpse, wrapped up in a sheet saturated with alum or asbestos, and placed on a metallic bed, passes over rollers into *a bath of rosy light*. The sheet delineates the form of the human body until incineration is complete, and the bones crumble into ashes under the mystic touch, as it were, of an invisible agent. This process may be called the etherealization or spiritualization of the human body. It requires about an hour per one hundred pounds of the original weight. A few pounds of clean, white ashes are dropped by means of a lever into the ash chamber below, and are drawn thence into an urn of terra-cotta, marble, alabaster, or other suitable material, and returned by means of the elevator to the catafalque. The service or ceremony being now over, the friends of the deceased find the ashes just where they had last seen the body of the departed, and may bear them thence to the columbarium or mortuary chapel, or set them on the border and plant violets, heartsease, and forget-me-nots in them from year to year. Each urn contains the ashes of but one person, as a rule, and has an appropriate inscription. The process is accompanied with no perceptible sound, smell, or smoke, and presents absolutely nothing that can offend the susceptibilities of the most fastidious.

Scarcely an instance, says Beugless, is known of anyone having witnessed the process as thus conducted who has not at once become a pronounced convert to cremation, whatever may have been his pre-existing prejudice.

Connected with the crematorium are rooms for post-mortem examinations and medico-legal researches, when deemed necessary.

Crematory temples, in many large cities of Europe, are of beautiful monumental architecture. Italy alone boasts of thirteen such temples. Milan has two. Those of the latter city and the one of Rome are of the grandest proportions. There exist to-day cremation societies in all countries of the world. There are not less than thirty-seven in Italy alone. The most important and most active is in Milan, which city is also the centre of the "Lega Italiana delle Società di Cremazione." The Cremation Society of Copenhagen numbers two thousand members, that of Holland twelve hundred members, that of Paris six hundred. There are also societies in Berlin, London, Dresden, Rio Janeiro, etc.; and in the United States there are not less than ten regularly incorporated organizations. Among their members are to be found some of our most distinguished citizens.

The greatest practical objection to the generalization of cremation was, until recently, the want of a proper apparatus for the *rapid* and *complete* incineration of bodies. That objection exists no longer—the problem is now solved by the late experiments made in Europe and in our own country. Great progress has been made in the different apparatuses. Venini's, which is used in Milan, Padua, Brescia, and Udine (Italy), seems, so far, to be the most perfect. It destroys most thoroughly all animal gases, is fumivorous (smoke-destroying), emits no smell, and its action is continuous. It is heated by *gas*, with variable oxidation, and its jets can be subdivided and concentrated on one point at will. By this apparatus the most rapid and hygienic, and at the same time least expensive, method of cremation has been obtained. As we have said before, the cost of cremating one body has been reduced in Milan to the sum of 8 francs ($1.60).

In Italy they have already built, in addition to their numerous beautiful crematorium temples in cities, large crematory furnaces (*forni collettivi*) for the cremation of bodies in time of war, especially of those who fall on the battlefields, and during epidemics for those who die from contagious or infectious diseases. These furnaces have been constructed according to Gorini's plan. It has been estimated that three of these *forni crematorii collettivi* could incinerate ten thousand bodies in three days.

A movable crematorium, on wheels, intended for an army in the field, or for localities in which crematory temples do not exist, has been invented by Captain Rey, of the Italian army, and has, upon trial, given perfect satisfaction. This apparatus, which can be easily drawn by two horses, does not cost over 3,000 francs ($600).

The main object of cremation societies, for some time to come, should be to enlighten public opinion, to remove all prejudices against cremation, and to prove that it can be practised without in the least wounding religious sentiment or susceptibilities. For, with so many powerful sanitary, philosophical, and economical arguments in favor of cremation, why is it that this essentially useful and hygienic measure is not more generally adopted in our country? Is it not simply on account of the ignorance, bigotry, and prejudice that surround us? Is it not the duty and mission of hygienists, philosophers, and sanitarians to attempt to enlighten the people, to advise legislation, to remove prejudice and false ideas, to prepare public opinion for the adoption of one of the greatest sanitary reforms of the age, which is intended to bring sanitary results of incalculable importance? Let our people understand and appreciate the immense benefit of cremation; let prejudice and bigotry be conquered. Cremation, once known, will become popular among us, and science will have made one more great step forward.

Principal Cremation Societies Existing in Italy, with Date of Their Organization.

Milan	1876	Varese	1880	Padua	1881
Lodi (municipal institution)	1877	Domodossola	1880	Codogno	1881
Cremona	1877	Como	1881	Venice	1882
Udine	1879	Bologna	1881	Plaisance	1882
Rome	1879	Modena	1881	Leghorn	1882
		Pavia	1881	Novara	1882
Ancona	1882	Parma	1882	Pistoja	1883
Genoa	1882	Verona	1882	Siena	1883
Florence	1882	Pisa	1882	St. Remo	1883
Brescia	1882	Carpi	1882	Intra	1884
Turin	1882	Asti	1883		

Felix Formento.

DEAD FINGERS. See *Hand and Fingers.*

DEAF-MUTES. — Definition and Classification. The word "deaf-mutes" signifies, strictly speaking, persons who, having been born deaf or having lost their hearing in early life, have not acquired the power of speech. There is usually no defect in the vocal organs, except such imperfection of development as may be the result of lack of exercise; muteness is simply the consequence of deafness. Ordinary children learn to speak by hearing and imitating the sounds made by others; the deaf child does not hear such sounds, therefore does not imitate them, therefore remains mute.

The term "deaf-mutes" seems to have originated in the United States within the present century. The synonymous term generally employed in England and still frequently used in this country, is "deaf and dumb." Of these two designations, "deaf-mute" is the preferable one; for (1) the words "deaf and dumb" tend to perpetuate the popular error that deafness and dumbness are two distinct physical defects, instead of standing, as above explained, in the relation to each other of cause and effect; and (2) the word "dumb" is open to the further objection that it carries with it an implication of stupidity and brutishness, being associated in the minds of many people with disparaging allusions to the lower animals, as in the Scriptural expression "dumb dogs," and in Longfellow's reference to "dumb, driven cattle."

There are many persons usually spoken of as "deaf-mutes," or "deaf and dumb," and educated in institutions established for the instruction of this class, who are not properly described by either of these terms. Some of them, having lost their hearing by accident or disease, after they had learned articulate language, still retain their speech notwithstanding their deafness; others, formerly mute, have acquired the art of speech through the instruction of skilful teachers of articulation. Such persons are not really "dumb" or "mute," and their improper classification as such—especially in the case of those who have learned to speak before losing their hearing—gives rise to serious errors in the mind of the public concerning the nature of deaf-mute education and its results. The strictly correct designation for the whole class of persons under consideration in this article is "the deaf"; the term "deaf-mute" should be applied only to persons deaf from birth or infancy, who have not acquired the use of articulate speech.

Some deaf-mutes are either born deaf, or, losing their hearing in early infancy from unobserved causes, are supposed to have been so born; others become deaf from various diseases or from accidents. The deaf are thus divided into two great classes: the "congenitally" and the "adventitiously" deaf, or, as they are often called, "congenital deaf-mutes" and "adventitious deaf-mutes." Except when hearing is known to have existed, it is impossible to say positively to which of these classes a deaf-mute belongs (see Proportion of Congenital and Adventitious Cases, *infra*); the distinction nevertheless is an important one.

Among the adventitiously deaf, a large proportion lose their hearing in early childhood, before they have learned articulate language; in other cases in which some progress in speaking has been made, the length and severity of the disease that causes deafness, often temporarily affecting the brain at the same time, seem to efface the language previously acquired; and in others the neglect of parents and friends to aid and encourage the deaf child in the extraordinary efforts necessary for the retention of speech after hearing is lost, produces the same result. Such persons are sometimes called "quasi-congenital deaf-mutes." Speech as well as hearing is gone, and they as truly belong to the class of "deaf-mutes" as if they had never heard.

Many persons have lost their hearing by accident or disease, after having acquired the use of articulate speech, and retain this speech more or less perfectly notwithstanding their deafness. If the loss of hearing occurs in adult life, they usually escape the improper classification with deaf-mutes above referred to; but if it happens in childhood, so that they cannot be educated in the usual manner of hearing children, but must be sent to special schools for instruction, they are erroneously included among deaf-mutes. Many of the processes of deaf-mute instruction are, it is true, equally applicable to persons of this class, and they may therefore properly be associated with deaf-mutes for the purpose of education; but they differ from deaf-mutes essentially, not only in having the ability to express themselves orally, but still more in their natural mode of thought, which is in words and not in gestures. This difference is fully recognized by all teachers of the deaf, who in this country distinguish the members of this class by the useful and convenient, though not accurately descriptive, title of "semi-mutes."

The deaf may be further classified according to the degree of their deafness. Deafness varies all the way from a slight difficulty in hearing to the inability to perceive the loudest sounds. Persons in whom the defect is so slight as to allow of their education through the ear in ordinary schools, are not regarded as deaf-mutes, and do not come within the scope of the present article; they may be designated as simply "hard of hearing." The whole class of the deaf, aside from the hard of hearing, are divided into "the totally deaf" and "the semi-deaf." The totally deaf may belong either to the congenital or to the adventitious classes, and the same is true of the semi-deaf.

The term "mute" is often used as synonymous with deaf-mute, but it should be avoided as less exact, since it may also refer to persons who hear, but are not able to speak on account of feeble mental power or of some defect in the vocal organs. It is open to the further objection that it suggests to many minds an undertaker's assistant at a funeral. Persons "mute" or "semi-mute," but not deaf, are, of course, not to be included among deaf-mutes, and are not suitable candidates for admission to schools for the deaf. If, as is usually the case, their deafness is due to defective mental power, they may properly be sent to a school for the feeble-minded, where the skilful efforts of devoted teachers often succeed in awakening the dormant intellect, imparting speech, and restoring the child to society.

Extent of Deaf-mutism.—For a large part of the world we have, of course, no statistics of deaf-mutism; but during several decades most of the countries of Europe and North America have included such statistics in their census returns. The returns from different countries, and from different parts of the same country, show remarkable differences in the extent of deaf-mutism. These differences are doubtless due in part to the greater accuracy with which the census is taken in some places than in others; but it is probable that place of residence, race, and modes of living have considerable influence. Mountainous regions give a larger proportion of deaf-mutes than low, level countries; the Caucasian than the African race; Jews than Christians; the poor and ignorant than the intelligent and well-to-do classes. Switzerland has the largest proportion of any country of which we have returns, 2,402 deaf-mutes in every million inhabitants; Australia has the lowest, 371 in every million. In the United States, according to the census of 1890, the proportion is 648 in every million.

Proportion of Males and Females.—In each million of population of the United States, of the same sex, according to the census of 1890, there were 702 male and 595 female deaf-mutes. Out of each thousand deaf-mutes there were 552.5 males and 447.5 females. The census returns of all other countries show a similar excess of male over female deaf-mutes. The greater liability of male children to ear and brain disease has been assigned as a reason for this excess, but the reason for such greater liability, if it really exists, has not been explained.

Proportion of Congenital and Adventitious Cases.—The census returns of 1890 give 41.5 per cent. of the total number of deaf-mutes in the United States as congenitally deaf, 50.5 per cent. as adventitiously deaf, and 8 per cent. as unknown. This result differs from that of all previous United States censuses, which make the congenitally deaf in the majority, as do also the censuses of foreign countries. On the other hand, statistics of pupils in schools for the deaf, in America and Europe alike, give an excess of adventitious over congenital cases. Of 23,931 pupils in American schools for the deaf, 9,842, or 41 per cent., were reported as congenitally deaf, and 14,089, or 59 per cent., as adventitiously deaf. These school statistics are unquestionably more trustworthy than census returns in general, inasmuch as the inquiries made by heads of schools on the admission of pupils are more intelligent and careful than those of the census enumerators.

It should be remembered, however, that all statistics concerning congenital and adventitious deafness are somewhat questionable, for the fact of congenital deafness cannot be determined with absolute certainty in any case. At the moment of birth it is impossible to find out whether the power of hearing exists or not, though a few days later, probably, this can be ascertained by applying proper tests. Generally, the fact of deafness is not discovered until the child arrives at the age when children usually begin to talk; at that time it is impossible to say whether the deafness has existed from birth or has occurred at some subsequent period. If the child has suffered from some unmistakable disease that is known to be a frequent cause of deafness, the case is likely to be recorded as adventitious; it may possibly, however, have been congenital. If, on the other hand, no such disease has been observed, the case is likely to be recorded as congenital; but it is, perhaps, quite as likely that the hearing has been lost in consequence of some unnoticed inflammation of the mucous membrane of the tympanic cavity or of the air passages occurring soon after birth, or at some subsequent time before the deafness was discovered. Deafness truly congenital is probably of much rarer occurrence than is indicated by even the most trustworthy statistics, and the only adventitious cases of which we can be sure are those of persons of whom it is known that they have heard at some period of their lives. It is to be understood, therefore, that "congenitally deaf," as a rule, really means "supposed to be congenitally deaf," and that "adventitiously deaf," in some cases, means "supposed to be adventitiously deaf." Of the adventitiously deaf a large proportion lose their hearing under five years of age.

Causes of Deaf-mutism.—The immediate cause of mutism, in the great majority of persons who do not speak, is simply deafness. (See Definition and Classification, *supra.*) Where this is not the case, as occasionally occurs in children improperly brought to schools for the deaf, there is usually some mental defect which has prevented the development of speech. Such mutism "is the result of the absence either of ideas or of reflex action in the motor organs of speech. In the former case, imbeciles have nothing to say; in the latter, they feel no desire to speak." Very rarely, indeed, it happens that mutism is due to some defect or paralysis of the vocal organs that interferes with articulation. But as neither of these groups of "hearing mutes" belongs to the class of deaf-mutes, they do not come within the scope of the present topic. Since deafness is the immediate cause of mutism in all deaf-mutes, in order to ascertain the causes of deaf-mutism we must inquire into the causes of deafness.

The causes of deafness may be divided into direct and indirect causes. The direct causes are the defects in the organ of hearing, whether congenital or adventitious, which prevent the perception of sound. The indirect causes are the circumstances of environment, disease, or accident, either ante-natal or post-natal, or both, accompanying or preceding deafness in so large a number of cases as to give us reason to suppose that they have an important influence in producing those defects. The causes of which I shall speak are those that have been observed by teachers of the deaf, or gathered by them from the statements of the parents and friends of the children brought to them for instruction.

In discussing this subject it has until recently been usual, setting out with the classification of deaf-mutes into congenital and adventitious cases, to ascribe all the former to ante-natal, and all the latter to post-natal, causes. This distinction cannot be maintained. There are probably both congenital and adventitious cases (though a much smaller number of the former than is generally supposed), and there are, doubtless, both ante-natal and post-natal causes; but (see Proportion of Congenital and Adventitious Cases, *supra*) it is impossible in any case of supposed congenital deaf-mutism to say certainly that it is not adventitious, while, as will appear below, there is reason to believe that ante-natal causes often combine with post-natal to produce adventitious deafness. Every case should be considered by itself; just as careful inquiry should be made, on the one hand, concerning all possible ante-natal causes in cases known to be adventitious as in those supposed to be congenital, and, on the other, concerning all possible post-natal causes in cases supposed to be congenital as in those known to be adventitious. This has not usually been done; when it is, we may expect to arrive at a much clearer understanding of the causes of deafness than has yet been reached.

Heredity.—The first, and probably the most effective, indirect cause of deaf-mutism is heredity. This is sometimes questioned, for the reason that deaf-mute parents do not, as a rule, have deaf-mute children; but, aside from the fact that the exceptions to this rule are of themselves numerous enough to establish the principle of heredity, its existence is clearly proved by the large number of deaf-mutes who are related to one another by blood. Out of 17,833 pupils who attended American schools for the deaf, 7,516, or 42 per cent., were reported as having deaf relatives. Many of these cases had more than one deaf relative, making the groups of related deaf-mutes much fewer than the total number of related deaf-mutes reported; but they none the less forcibly illustrate the tendency of deafness to prevail in certain families—a tendency which can be explained only by the principle of heredity. As Prof. W. K. Brooks has profoundly observed, "an inherited characteristic may or may not have been manifested by the parents or other ancestors. If it is more common either among the ancestors or the brothers and sisters and cousins of the organism than it is in the race at large, it is an inherited characteristic."

Of 2,245 deaf persons reported as congenitally deaf, 1,461, or 65 per cent., had deaf relatives; of 3,953 reported as adventitiously deaf, 794, or 20 per cent., had deaf relatives. The large proportion of cases supposed to be congenital, among those having deaf relatives, indicates that the hereditary tendency to deafness, where it exists, is generally so strong as to produce the result—whether independently or in conjunction with some other indirect cause that is not observed—either before or soon after birth; while the considerable number of known adventitious cases having deaf relatives shows that the inherited tendency not infrequently awaits the concurrence of some disease, perhaps not hereditary in its character, before manifesting itself. It should be remembered also that, though we speak of hereditary deafness, what is inherited in any case of deafness, whether congenital or adventitious, is not really deafness, but some anomaly of the auditory organs or of the nervous system, or the tendency to some disease, of which deafness is but the result or the symptom.

While the principle of heredity is thus clearly established as an indirect cause of deafness, it is the fact that in a great majority of cases the defect is not transmitted by deaf parents to their children. Still, marriages of the deaf are more likely to result in deaf offspring than ordinary marriages. Of 3,078 marriages of deaf persons in America, one or both of the partners being deaf, the results of which are known, 300, or nearly 10 per cent., resulted in deaf offspring; of the 6,782 children born of these marriages, 588, or 8.5 per cent., were deaf. The percentage of ordinary marriages resulting in deaf offspring is not known; it is certainly less than one per cent. The results above stated are in accordance, on the one hand, with the law of heredity that a physical anomaly or an unusual liability to certain diseases existing in the parent tends to be transmitted to the offspring, and, on the other hand, with the law of heredity that the offspring tend to revert to the normal type.

For the hereditary transmission of the physical condition that results in deafness, it is not necessary that both of the partners in marriage should be deaf. On the contrary, taking the deaf as a whole, without regard to the character of the deafness, marriages in which both of the partners are deaf are not more liable to result in deaf offspring than those in which one of the partners is deaf and the other a hearing person. Of 2,377 marriages in which both partners were deaf, 220, or 9.25 per cent., resulted in deaf offspring; of 599 marriages in which one partner was deaf and the other hearing, 75, or 12.5 per cent., resulted in deaf offspring. Of 5,072 children born of the marriages in which both partners were deaf, 429, or 8.5 per cent., were deaf; of 1,532 children born of the marriages in which one partner was deaf and the other hearing, 151, or nearly 10 per cent., were deaf. These results are not, as it might appear at first sight, inconsistent with the general law of heredity that the liability to the transmission of any characteristic existing in the parent is increased by the union of "like with like"; for, as has been stated above, when the deafness of the parent appears in the offspring, the characteristic transmitted is not deafness, but is some anomaly of the auditory organs or of the nervous system, or the tendency to some disease, of which deafness is but the result or the symptom. Inasmuch as these anomalies and diseases resulting in deafness are many and various, it is probable that in most marriages of deaf persons the pathological condition that results in deafness is not the same in one partner that it is in the other, and their marriage, therefore, is not, from a physiological point of view, a union of "like with like." On the other hand, where the pathological condition of the two partners is the same, as it probably is in the majority of consanguineous marriages of deaf persons, there is doubtless an intensification of the liability to deaf offspring. Of 31 consanguineous marriages of deaf persons, 14, or 45 per cent., resulted in deaf offspring, and of 100 children born therefrom, 30 were deaf. Fortunately such marriages are rare.

Congenitally deaf persons, whether they are married to one another, to adventitiously deaf, or to hearing partners, are far more liable to have deaf offspring than are adventitiously deaf persons. The liability is greatest when both of the partners are congenitally deaf. Of 335 marriages in which both partners were reported as congenitally deaf, 83, or 25 per cent., resulted in deaf offspring; and of the 779 children born from those marriages, 202, or 26 per cent., were deaf.

Marriages of adventitiously deaf persons are more liable to result in deaf offspring than ordinary marriages, but when both of the partners are adventitiously deaf or one of them is a hearing person the liability is slight. Of 845 marriages in which both partners were adventitiously deaf, 30, or 3.5 per cent., resulted in deaf offspring; of the 1,720 children born from these marriages, 40, or 2 per cent., were deaf. Of 310 marriages in which one partner was adventitiously deaf and the other hearing, resulting in 713 children, the percentages of marriages resulting in deaf offspring and of deaf children born therefrom were nearly the same as in the marriages in which both partners were adventitiously deaf. The greater liability to deaf offspring in marriages of the congenitally deaf than in those of the adventitiously deaf is in accordance with the generally accepted law of heredity that congenital or innate characteristics are far more likely to be transmitted to the offspring than acquired characteristics. When the deafness of adventitiously deaf parents does reappear in the offspring we may suppose that the physical anomaly or tendency to disease of which deafness was the result was probably congenital in the parent, though actual deafness did not appear until some period later in life.

Deaf persons having deaf relatives, however they are married, and hearing persons having deaf relatives and married to deaf partners, are very liable to have deaf offspring. (Probably hearing persons having deaf relatives and married to hearing partners are subject to the same liability, but while many instances of marriages of this kind resulting in deaf offspring have been observed, no thorough and systematic investigation of them has yet been made.) However the marriages of the deaf are classified with respect to the deafness or hearing of one or both of the partners, or with respect to the congenital or adventitious character of the deafness, the percentage of marriages resulting in deaf offspring and of deaf children born therefrom is almost invariably highest where both of the partners had deaf relatives, next highest where one of them had deaf relatives and the other had not, and least where neither had deaf relatives. Where neither of the partners has deaf relatives, even though both of them are congenitally deaf, the liability to deaf offspring is very slight, perhaps not greater than in ordinary marriages. While congenital deafness, then, may be a *prima facie* indication of a liability to deaf offspring, it is not to be accepted as a conclusive evidence of such liability; but the possession of deaf relatives does seem to be a trustworthy indication of a liability to deaf offspring. If a deaf person, whether congenitally or adventitiously deaf, has deaf relatives, that person, however married, is liable to have deaf offspring, the liability being much greater, however, in the case of the congenitally deaf than of the adventitiously deaf; and if a deaf person, either with or without deaf relatives, marries a person, whether deaf or hearing, who has deaf relatives, the marriage is liable to result in deaf offspring. If both partners have deaf relatives, the physical conditions tending to produce deafness, whatever they may be, are liable to be transmitted from both parents, and the probability of deaf offspring is therefore largely increased; but even where only one of the partners has deaf relatives the liability to deaf offspring is still considerable.

The following table gives a summary of the 3,078 marriages having one or both of the partners deaf, from which the conclusions above stated are derived. The table shows the number of marriages of each class, the number and percentage of each class resulting in deaf offspring, the number of children born from the marriages of each class, and the number and percentage of them that were deaf. The fifth and sixth columns of this table, giving the percentage of marriages resulting in deaf offspring and the percentage of deaf children born therefrom, indicate at a glance the comparative liability to deaf offspring of the several classes of marriage. The extremes of liability are found in the two classes last named in the table.

Marriages of the deaf.	NUMBER OF MARRIAGES.		NUMBER OF CHILDREN.		PERCENTAGE.	
	Total.	Resulting in deaf offspring.	Total.	Deaf.	Marriages resulting in deaf offspring.	Deaf children.
One or both partners deaf.....	3,078	300	6,782	588	9.7	8.6
Both partners deaf............	2,377	220	5,072	429	9.2	8.4
One partner deaf, the other hearing....................	599	75	1,532	151	12.5	9.8
One or both partners congenitally deaf..................	1,477	194	3,401	413	13.1	12.1
One or both partners adventitiously deaf	2,212	124	4,701	199	5.6	4.2
Both partners congenitally deaf	335	83	779	202	24.7	25.9
One partner congenitally deaf, the other adventitiously deaf	814	66	1,820	119	8.1	6.5
Both partners adventitiously deaf	845	30	1,720	40	3.5	2.3
One partner congenitally deaf, the other hearing...........	191	28	528	63	14.6	11.9
One partner adventitiously deaf, the other hearing......	310	10	713	16	3.2	2.2
Both partners had deaf relatives........................	437	103	1,060	222	23.5	20.9
One partner had deaf relatives, the other had not	541	36	1,210	78	6.6	6.4
Neither partner had deaf relatives...........	471	11	1,044	13	2.3	1.2
Both partners congenitally deaf; both had deaf relatives	172	49	429	130	28.4	30.3
Both partners congenitally deaf; one had deaf relatives, the other had not	49	8	105	21	16.3	20.0
Both partners congenitally deaf; neither had deaf relatives.......................	14	1	24	1	7.1	4.1
Both partners adventitiously deaf; both had deaf relatives	57	10	114	11	17.5	9.6
Both partners adventitiously deaf; one had deaf relatives, the other had not...........	167	7	357	10	4.1	2.8
Both partners adventitiously deaf; neither had deaf relatives.......................	284	2	550	2	.7	.0
Partners consanguineous	31	44	100	30	45.1	30.3

Consanguinity of Parents.—Heads of schools for the deaf, observing that a considerable number of their pupils are the children of parents related by blood, generally believe that consanguineous marriages are a frequent cause of deaf-mutism. Of 13,271 pupils in American schools, 1,028, or 7.75 per cent., were the children of first cousins. We do not know the proportion of marriages of first cousins to all marriages, but it is probably considerably less than 7.75 per cent.; if so, we may conclude that such marriages are more likely to result in deaf offspring than ordinary marriages. The reason is, probably, not that consanguineous marriage in itself is a true cause of deaf-mutism, but that in some families there exists a tendency to deafness, and when two persons belonging to such a family marry, the tendency is transmitted to their offspring with increased intensity, and deaf-mutism is the result. The disastrous effects of deaf-mutes marrying their relatives are shown in the 31 cases above cited, 45 per cent. of which resulted in deaf offspring, producing 30 deaf children out of 100. In 18 of these cases one of the partners was a hearing person; if the other partner had also been hearing, but a member of the same family, the results would probably have been equally unfortunate. Even when no hereditary tendency to deafness is known to exist in a family, relatives should generally be advised not to marry; for, as Mr. George H. Darwin suggests, no man knows with certainty, until toward the end of life, what ills may lie hidden in his edition of the family constitution.

Social Circumstances. — Unfavorable social circumstances, poverty, and ignorance may probably be classed among the indirect causes of deaf-mutism, since the proportion of deaf-mutes among these classes seems to be greater than in the whole community. This is a matter of common observation rather than of statistical record, but it is certainly reasonable to suppose that negligence, damp and ill-ventilated dwellings, insufficient nourishment, the lack of proper medical treatment, and other evils springing from poverty and ignorance, may combine with more direct causes to produce deafness.

Mountainous Regions.—The large percentage of deaf-mutes in Switzerland, as compared with all other countries of which we have statistics (see Extent of Deaf-

Mutism, *supra*), and of the more mountainous regions of Switzerland, Austria, France, Spain, and Germany, as compared with the lower and more level districts (45 in 10,000 in Berne, Lucerne, and Wallis, to 24.5 in the whole of Switzerland; 30.6 in Salzburg, Steiermark, and Carinthia, to 9.7 in all Austria; 24.5 in the Alpine departments of France to 6.26 in the whole country; 10.4 in South Germany to 6.05 in North Germany) shows that there must be some influence in mountainous countries which, in some manner, tends to cause deaf-mutism. The opponents of consanguineous marriages charge the result to the kinship of the parents, who are said to be more likely to be related to each other than in the lowlands, on account of the scanty means of communication between different districts; others, who attach much importance to social conditions, ascribe it to the poverty of mountainous regions, and the close, unhealthy houses in which the people live in winter; others to the dampness and coldness of the climate; others to the use of certain waters, which, it is said, are also a cause of the goitre, cretinism, and other anomalies often found in Switzerland in the same families with deaf-mutism. We must await a fuller knowledge of all the causes of deaf-mutism, and of all the circumstances of mountaineers, before we can explain this phenomenon satisfactorily.

Other Remote Causes.—Other remote causes which appear to have some influence in producing deaf-mutism are general debility, alcoholism, and syphilis in one or both of the parents, and influences exerted during pregnancy. It is difficult to prove any of these causes statistically, because, as Hartmann and Mygind have remarked, the reports are often uncertain, and also because we have no statistics as to other large groups of individuals with which to draw comparison. It seems probable, however, that deaf-mutism, as Féré insists, is often the result of diseases of the nervous system, and that diseases of this character in the parent may affect the offspring in such a way as not only to produce congenital deafness, but also to render the children more likely to become deaf from other diseases after birth. Alcoholism especially has been noted in a good many parents of deaf children, both of those congenitally and of those adventitiously deaf; probably the proportion of persons addicted to drink who have deaf children is greater than the proportion of persons thus addicted is to the community at large. Granting that a connection exists between alcoholism and deaf-mutism, the question still remains whether the cause of the deaf-mutism is alcoholism or a morbid condition of the nervous system of which the alcoholism is a symptom and result.

Fright or some other influence acting on the mind of the mother during pregnancy is frequently assigned by parents or friends as a cause of deaf-mutism, and striking narratives, especially with respect to gesticulating deaf-mutes seen by the mother for the first time during that period, are related in support of the theory. Inasmuch, however, as further inquiry usually brings to light other causes which seem to be adequate, we need not accept this as a true cause. On the other hand, injuries to the mother producing abnormal compression of the embryo and thus arresting the development of some parts, may perhaps occasion deaf-mutism. Dr. Saint-Hilaire attributes some cases of deafness in illegitimate children to the mother's efforts to conceal her condition by extremely tight lacing during pregnancy.

Diseases and Accidents.—Turning to the causes which more unmistakably produce deafness after hearing is known to have existed, statistics show that it so often follows certain diseases and accidents as to leave no room for doubt that these diseases and accidents may be counted as true causes, though there are probably often ante-natal influences which combine with these causes to produce the result. The assigned causes of 16,769 cases of adventitious deafness, according to the census of 1890, were as follows:

Inflammation and abscess of the ear	1,033
Other diseases of the ear	157
Smallpox	72
Measles	1,021
Scarlet fever	4,799
Diphtheria	222
Whooping-cough	361
Mumps	106
Malarial and typhoid fevers	771
Paralysis	132
Scrofula	337
Meningitis	3,278
Hydrocephalus	61
Other diseases of the brain	220
Diseases of the throat and air passages	1,354
All other diseases	2,845
Blows and falls	671
Other accidents	590
Quinine	147

Scarlet fever is the most frequently assigned cause for deafness, including more than one-fourth of the whole number for whom the causes are reported. Next come meningitis and hydrocephalus, being about 18 per cent. Other percentages are: Diseases of the throat and air passages, 7.5 per cent.; measles, 5.5 per cent.; malarial and typhoid fevers, 4 per cent.; scrofula, 2 per cent.; whooping-cough, 2 per cent.; diphtheria, 1 per cent.; mumps, 0.6 per cent.; accidents, 7 per cent.

In a list of the causes of deafness of 12,380 pupils who have attended American schools for the deaf, meningitis, instead of scarlet fever, stands at the head with 24 per cent., and scarlet fever comes next with 23 per cent. Other causes do not differ greatly from the percentages given above.

Correlation of Deaf-mutism with Blindness, etc.—According to the census of 1890, 295 persons in the United States were deaf-mute and blind, 409 deaf-mute and insane, 1,373 deaf-mute and feeble-minded, 62 deaf-mute, blind, and insane, and 137 deaf-mute, blind, and feeble-minded. It is probable that a considerable number of those returned as deaf-mute and feeble-minded were not really deaf, but were mute from mental incapacity; that some of those reported as deaf-mute and blind were persons whose hearing or sight or both had failed in their old age; and that many reported as deaf-mute and insane were uneducated deaf-mutes whose social condition and environment were such as would tend to produce insanity.

There is no doubt, however, that there does really exist in a considerable number of cases a correlation between deaf-mutism and these other misfortunes, which is perhaps to be attributed to a diseased condition of the nervous system inherited from neuropathic or alcoholic parents. Even when deafness alone appears, the other defects referred to are sometimes found in other members of the same family.

Another circumstance bearing upon this question is brought out in a table of the census returns of 1890 showing that the ratios of the congenitally deaf, the congenitally blind, and the congenitally feeble-minded increase or decrease together in a majority of the several States and Territories of the Union. Virginia and North Carolina, for instance, which stood highest of all the States in the ratio of deaf-mutes, were also among the highest in the ratios of the blind and feeble-minded, while the States and Territories west of the Rocky Mountains had the lowest ratio of all three classes.

This correlation of deaf-mutism with other misfortunes in the same person or in other members of the family has led Dr. Saint-Hilaire to regard deaf-mutism as a form of degeneracy, and Dr. Féré has observed in the pupils of the Paris Institution and other deaf-mutes who have come under his observation some of the recognized marks of degeneracy. No doubt there are deaf-mutes who may properly be classed as degenerates, but we do not find in the facts presented by these writers any sufficient reason for regarding deaf-mutism in general as a form of degeneracy.

MENTAL CONDITION AND CHARACTERISTICS.—With respect to mental condition and characteristics, the division of the deaf into several distinct classes, mentioned at the beginning of this article, is of the greatest importance. Semi-mutes, who have acquired an idiomatic use of spoken language before hearing was lost, retain to a greater or less degree the modes of thought and mental characteristics of hearing persons. They think in words and express themselves easily and naturally in the language of their childhood. In the course of time, especially if they are not encouraged to use the voice in conversing with others, they may lose their memory of sound and may cease to pronounce words mentally; but even then, if they have learned to read and write, words in their written or printed form will serve them as natural and convenient instruments of thought.

Since semi-mutes, on account of their deafness, cannot, as a rule, be educated in common schools, and their number in any community is usually too small to justify the establishment of special schools for them, they are educated with deaf-mutes, many of the processes of instruction beyond the elementary stage being equally applicable to both classes; but the semi-mute always has a great advantage over his deaf-mute classmate in his command of language. This distinction, though it is often explained by candid teachers, is not always understood by visitors to the school-room; and the public are thus sometimes misled as to the actual attainments of deaf-mutes. In mental vigor, and in the acquisition of general knowledge, the true deaf-mute, notwithstanding he is heavily handicapped in respect to language, will not infrequently surpass the semi-mute; but most of the cases of remarkable facility in composition and of great success in articulation that astonish the undiscriminating public at exhibitions, belong to the class of semi-mutes, as do also nearly all the deaf persons who have distinguished themselves in later life as authors and poets.

Between the semi-mute and the congenital deaf-mute, but more closely allied with the latter than the former, stands the "quasi-congenital" deaf-mute. He retains no conscious memory of words; he must acquire written language or vocal speech by the same laborious processes as if he had never heard; in his attempts at composition he makes the same curious mistakes as the congenital deaf-mute; and yet it is a fact often observed by teachers that children of this class do learn language more easily and successfully, and adapt themselves more readily to the modes of thought of hearing persons, than those who are born deaf or lose their hearing soon after birth. When we remember how vivid are the impressions of childhood, how full a vocabulary, and how much fuller a comprehension of language as spoken by others, a bright child obtains during the first two or three years of his life, it is not strange if the mental condition of one who loses hearing when he has reached this age is essentially different from that of one who has never heard. The wonder is rather that, of the immense mental and linguistic acquisitions he has made through the sense of hearing, so little appears to remain.

The uneducated deaf-mute who has never heard, or whose hearing has been lost in early infancy, has no knowledge whatever of the language of words. This lack of language is the key to his mental condition and characteristics. He has an intelligent mind; he observes, reasons, and forms conclusions; but his train of thought, being carried on by means of mental pictures and rude gestures, is imperfect and incomplete, while his reasoning, being based upon his own limited range of observation uncorrected by the superior wisdom and wider experience of others, is apt to lead him to erroneous conclusions. Careful inquiries made of educated deaf-mutes with respect to their ideas before instruction have elicited the fact that, although—like young children in general—they usually accept the phenomena of nature as a matter of course, and do not trouble themselves concerning their origin, yet they do sometimes reflect on these subjects and frame for themselves various fanciful explanations of the means by which the more striking natural phenomena are produced; as, for instance, that the wind is blown from a great bellows, that the rain is poured down through small holes in the sky, that snow is ground out like flour from a celestial mill, that thunder and lightning are the discharges of cannon, that the stars are candles or lamps lighted every evening, that death is caused by the medicine administered to the sick person, etc., etc. None seem to have arrived at the idea of the existence of the soul, nor of a God, nor of immortality; and there are only two instances on record in which they have reflected at all upon the origin of the world and its inhabitants. One girl, who had reached the age of fifteen before coming to school, said that she "had tried to think about it, but could not"; she "thought the people came from the South"; and one very intelligent boy, at the age of nine years, having gained from his own observation an idea of the descent from parent to child, the propagation of animals, and the production of plants from seeds, struggled long and earnestly with the question whence came the first man, the first animal, and the first plant; but, like many wiser men, without reaching any satisfactory conclusion.

The deaf-mute very early invents a language of signs sufficient for the expression of the common wants of his every-day life, and if he has intelligent friends who are ready to aid his attempts at the exchange of ideas in this way, or if he associates with other deaf-mutes, this language will be extended and elaborated to a high degree. It becomes his usual mode of thought; and while he may, after long years of effort by his teachers and himself, learn to think more or less in spoken or written words, the language of signs always remains his easiest and most natural method not only of expression but of thought. The language of words written or spoken is for him something strange, foreign, artificial; he may master it as the hearing student masters a foreign tongue, so that he will think in it to some extent, use it with considerable freedom, and read it understandingly and profitably; but, except in very rare cases of peculiar education and environment, the language of gesture is, and always remains, the vernacular of the deaf-mute.

The language of words being a foreign language to the deaf-mute, he is liable, even after years of instruction, to make mistakes in its use. Such mistakes of course become less frequent as his education advances; but the deaf-mute who has never heard, or who has lost his hearing in early infancy, rarely, if ever, acquires such a mastery of language as to employ it in speech or writing with the same readiness and freedom as persons who learn to speak in childhood through the hearing. The peculiarities in his phraseology are sometimes called "deaf-mutisms," and their origin has been ascribed by some writers to the inversions of the sign language; but their main cause, like that of the blunders of foreigners, is merely an incomplete knowledge of the language of words.

The characteristics of an uneducated deaf-mute, especially when in unfavorable social circumstances his natural language of signs has not been developed beyond its most rudimentary stage, are what might be expected. Cut off from communication with his kind, misinterpreting alike the order of nature and the actions of his fellow-men, he is apt to become melancholy, suspicious, treacherous, and cruel. The neglect on the part of parents and friends which, from any motive whatever, allows the deaf-mute child to grow up in this condition, when, as in the United States, the benefits of education are freely offered to all, is simply criminal.

A wisely conducted education, giving the deaf-mute writing or speech as a means of communication, and imparting just views of his relations to God and his fellow-men, tends to correct the defects above mentioned, and enables him to take his proper place in the world as an active and useful member of society.

Morbidity.—Since the maladies that cause deafness are in some cases the result of an imperfect physical constitution, and in others leave a previously sound constitution debilitated and impaired, we should expect to find the percentage of morbidity in persons of this class higher than among hearing persons. We have few records on this point except those of our schools, and the latter not in a statistical form; but it is the general testimony of the heads of schools that their pupils, as a rule, enjoy excellent health—quite as good as the average health of hearing children. This is probably due to the regular habits, wholesome food, well-ventilated rooms, good sanitary arrangements, and out-of-door exercise afforded by institution life, which counteract any unfavorable constitutional tendencies that may exist.

Tuberculosis was formerly regarded as a disease to which deaf-mutes were peculiarly liable, since statistics collected by Porter and Peet in this country, Wilde in Ireland, and Müller in Germany showed that a large proportion of deaths were due to this cause, but within recent years tuberculosis has not been observed to be especially prevalent among the deaf. The mortality from this cause in former times was probably due to bad sanitary conditions and to infection.

It is sometimes asserted that the lungs of deaf-mutes are ill developed on account of their lack of exercise in speech. But, aside from the fact that deaf children do generally use their voices considerably, making a great variety of sounds, the expansion of the lungs in respiration, as Hartmann says, really suffices for their proper development. A careful examination of the lungs of the students of Gallaudet College at Washington, with a view to cautioning them against violent gymnastic exercises in case of pulmonary weakness, showed only one out of fifty with any tendency in that direction.

MORTALITY.—There are no comparative tables on a scale sufficiently extended to enable us to form a definite conclusion as to the mortality of deaf-mutes as compared with hearing people. In Denmark during the years 1879–88 the mortality among adult deaf-mutes corresponded pretty nearly to the mortality among the laboring classes in Copenhagen, whose death rate was the highest of any class in Denmark; a result which Mygind attributes to their unfavorable social and sanitary conditions. The total numbers, however, were too small to be conclusive. At first thought it might be supposed that deaf-mutes are more liable than hearing persons to fatal accidents in the street, on the railway, etc., on account of their inability to hear warnings of danger; but this liability is probably more than offset by their greater habit of caution in such places. It is to be hoped that the necessary statistics for determining the rate of mortality of deaf-mutes may soon be afforded, for at present some insurance companies refuse to accept risks on their lives and others charge them more than the usual rates.

MARRIAGE.—Since the education of deaf-mutes has become general, marriage among them has ceased to be rare, especially in America. Of 27,924 pupils who attended American schools for the deaf up to the year 1890, statistics gathered during the past decade show that 6,460, or 23 per cent., have been married, and the actual per cent. of the married deaf in this country is probably much higher than that.

Marriages of deaf-mutes are slightly less productive than ordinary marriages. The proportion of 3,078 marriages of the deaf in America without offspring was 14.1 per cent., and the average number of children to each mother was 2.61.

In 72 per cent. of the marriages of the deaf recorded in America both of the partners were deaf. As has been shown above under "Heredity," marriages of this kind are not more liable to result in deaf offspring than those in which one of the partners is deaf and the other a hearing person; that they are more likely to be happy marriages, owing doubtless to the strong bond of mutual fellowship growing out of the similar condition of husband and wife, the ease and freedom with which they communicate with each other, and the identity of their social relations and sympathies, is proved by the statistics of divorces and separations. In the marriages of the deaf in America, where both of the partners were deaf, the proportion of the divorces and separations reported was 2.5 per cent.; where one of the partners was deaf and the other a hearing person, the proportion was 6.5 per cent.

In the case of deaf-mutes having no deaf relatives there is little, if any, danger that deafness will reappear in the offspring provided they marry persons, whether deaf or hearing, who have no deaf relatives. The liability to deaf offspring when either or both of the partners in marriage have deaf relatives has been mentioned above under "Heredity."

OCCUPATIONS.—Uneducated deaf-mutes can and do perform unskilled labor, but the competition here is so great, and they are at so much disadvantage in various ways as compared with hearing persons, that, though they are sometimes self-supporting, they are often more or less a burden upon their friends or upon the community.

With educated deaf-mutes the case is very different. In all of the large American schools the importance of industrial instruction is fully recognized and several hours of each day are devoted to this purpose. The occupations taught are, for the boys, baking, barbering, basket-making, blacksmithing, book-binding, bricklaying, broom-making, cabinet-making, carpentry, chair-making, coopery, engraving, farming, floriculture, gardening, glazing, harness-making, horticulture, mattress-making, painting, paper-hanging, plastering, photography, printing, shoemaking, tailoring, and wood-turning; for the girls, cooking, domestic and ornamental sewing, both with and without the machine, dress-making, ironing, knitting, millinery, shirt-making, tailoring, and the folding and stitching of sheets for the book-binder. Instruction in clay-modelling, drawing, decorating, etc., enables some of both sexes to engage in various pursuits of industrial art and in pure art. In some instances the pupils are made thorough masters of their trades while at school, so that they immediately command remunerative positions upon graduating; and even in the greater number of cases in which they merely acquire the principles of a trade, familiarity with the use of tools, dexterity, and habits of industry, they find it much easier to master the business afterward, or to learn some new trade, than would be possible if no attention had been paid to industrial education.

The list of occupations pursued by educated deaf-mutes includes not only the industries above mentioned as taught at school, but almost every pursuit that does not require the actual use of hearing and speech. The great majority are engaged in various branches of skilled industry; some are artists, or workers in industrial art; while among the more intelligent and highly educated, especially those who have enjoyed the advantages of the College at Washington, are many government clerks, many teachers of the deaf, several clergymen preaching to the deaf, and several editors, publishers, merchants, inventors, chemists, and lawyers.

LEGAL RIGHTS AND RESPONSIBILITIES.—Under the Justinian Code, deaf-mutes who could not read and write were classed with the insane and idiotic, and had therefore no legal rights nor responsibilities. A better comprehension of their mental condition has led to considerable modification of their legal status, so far at least as their rights are concerned. It has been decided repeatedly, both in England and America, that an uneducated deaf-mute who possesses sufficient intelligence to express his ideas, wishes, and intentions by signs can make contracts, execute deeds, dispose of property by gift or by testament, and give evidence in court. The degree of intelligence and facility of communication can usually be determined by the testimony of acquaintances or of experienced teachers of the deaf.

The uneducated but not unintelligent deaf-mute who commits crime against property—usually theft—is generally and properly held responsible for the act; but in the case of serious crime against the person—as, for instance, homicide under the provocation of cruelty—his moral and legal responsibility is not so easy to determine. In such cases, which have been unhappily frequent in proportion to the number of this class of persons, judges and juries, especially in view of the death penalty, have naturally shrunk from the decision that the deaf-mute without any education was morally and legally responsible, and he has either through an appeal by his counsel to the old law classing deaf-mutes with the insane and idiotic escaped trial altogether, or through the sympathy or the disagreement of the jury been acquitted.

Educated deaf-mutes who can communicate with others orally or by writing, occupy the same position before the law as hearing persons.

SCHOOLS FOR THE DEAF IN THE UNITED STATES.—There are 115 schools for the deaf in the United States, containing (November 10th, 1900) 10,608 pupils. Fifty-seven of these schools, with 9,504 pupils, are public boarding schools supported by the several States; of the remaining pupils, 708 are in public day schools and 396 in denominational and private schools. The various methods of instruction used in these schools may be defined as follows:

I. *The Manual Method.*—Signs, the manual alphabet, and writing are the chief means used in the instruction of the pupils, and the principal objects aimed at are mental development and facility in the comprehension and use of written language. The degree of relative importance given to these three means varies in different schools; but it is a difference only in degree, and the end aimed at is the same in all.

II. *The Manual Alphabet Method.*—The manual alphabet and writing are the chief means used in the instruction of the pupils, and the principal objects aimed at are mental development and facility in the comprehension and use of written language. Speech and speech-reading are taught to all of the pupils in one of the schools (the Western New York Institution) recorded as following this method.

III. *The Oral Method.*—Speech and speech-reading, together with writing, are made the chief means of instruction, and facility in speech and speech-reading, as well as mental development and written language, is aimed at. There is a difference in different schools in the extent to which the use of natural signs is allowed in the early part of the course, and also in the prominence given to writing as an auxiliary to speech and speech reading in the course of instruction; but they are differences only in degree, and the end aimed at is the same in all.

IV. *The Auricular Method.*—The hearing of semi-deaf pupils is utilized and developed to the greatest possible extent, and, with or without the aid of artificial appliances, their education is carried on chiefly through the use of speech and hearing, together with writing. The aim of the method is to graduate its pupils as hard-of-hearing speaking people instead of deaf-mutes. (This method, which has recently been brought to the notice of physicians by the experiments of Urbantschitsch, Bezold, and others, has been used in American schools for many years, but it is regarded as desirable for only a small proportion of the pupils.)

V. *The Combined System.*—Speech and speech-reading are regarded as very important, but mental development and the acquisition of language are regarded as still more important. It is believed that in many cases mental development and the acquisition of language can be best promoted by the Manual or the Manual Alphabet method, and, so far as circumstances permit, such method is chosen for each pupil as seems best adapted for his individual case. Speech and speech-reading are taught where the measure of success seems likely to justify the labor expended, and in most of the schools some of the pupils are taught wholly or chiefly by the oral method or by the auricular method.

The following table gives all the schools for the deaf in the United States existing in the year 1890, with their location, date of opening, and methods of instruction:

A.—PUBLIC SCHOOLS (NOT INCLUDING DAY SCHOOLS).

	Name.	Location.	Date of opening.	Methods of Instruction.
1	American School for the Deaf	Hartford, Conn	1817	Combined.
2	New York Institution for the Instruction of the Deaf and Dumb	New York, N. Y. (*a*)	1818	Combined.
3	Pennsylvania Institution for the Deaf and Dumb	Mount Airy, Philadelphia, Pa	1820	Oral and manual alphabet.
4	Kentucky Institution for the Education of Deaf-Mutes	Danville, Boyle Co., Ky	1823	Combined.
5	Ohio Institution for the Education of the Deaf and Dumb	Columbus, Ohio	1829	Combined.
6	Virginia School for the Deaf and the Blind	Staunton, Va	1839	Combined.
7	Indiana Institution for the Education of the Deaf and Dumb	Indianapolis, Ind	1844	Combined.
8	Tennessee Deaf and Dumb School	Knoxville, Tenn	1845	Combined.
9	North Carolina Institution for Education of the Deaf and Dumb and the Blind.	Raleigh, N. C	1845	Combined.
10	Illinois Institution for the Education of the Deaf and Dumb	Jacksonville, Ill	1846	Oral and manual alphabet.
11	Georgia School for the Deaf	Cave Spring, Ga	1846	Combined.
12	South Carolina Institution for the Education of the Deaf and the Blind	Cedar Spring, S. C	1849	Combined.
13	Missouri School for the Deaf	Fulton, Callaway Co., Mo	1851	Combined.
14	Louisiana Institution for the Education of the Deaf and Dumb	Baton Rouge, La	1852	Combined.
15	Wisconsin School for the Deaf	Delavan, Walworth Co., Wis	1852	Combined.
16	Michigan School for the Deaf	Flint, Mich	1854	Combined.
17	Mississippi Institution for the Education of the Deaf and Dumb	Jackson, Miss	1854	Combined.
18	Iowa School for the Deaf	Council Bluffs, Iowa	1855	Combined.
19	Texas Deaf and Dumb Asylum	Austin, Texas	1857	Combined.
20	Columbia Institution for the Deaf and Dumb	Kendall Green, Washington, D. C	1857	
	A. Kendall School for the Deaf	Kendall Green, Washington, D. C	1857	Combined.
	B. Gallaudet College	Kendall Green, Washington, D. C	1864	Combined.
21	Alabama Institute for the Deaf	Talladega, Ala	1858	Combined.
22	California Institution for the Deaf and the Blind	Berkeley, Alameda Co., Cal	1860	Combined.
23	Kansas School for the Deaf	Olathe, Kansas	1861	Combined.
24	Le Couteulx St. Mary's Institution for the Improved Instruction of Deaf-Mutes.	Buffalo, N. Y. (2253 Main Street)	1861	Combined.
25	Minnesota School for the Deaf	Faribault, Rice Co., Minn	1863	Combined.
26	New York Institution for the Improved Instruction for Deaf-Mutes	New York, N. Y. (904–922 Lexington Ave.)	1867	Oral.
27	Clarke School for the Deaf	Northampton, Mass	1867	Oral.
28	Arkansas Deaf-Mute Institute	Little Rock, Ark	1868	Combined.
29	Maryland School for the Deaf and Dumb	Frederick City, Md	1868	Combined.
30	Nebraska Institute for the Deaf and Dumb	Omaha, Neb	1869	Combined.
31	St. Joseph's Institute for the Improved Instruction of Deaf-Mutes	Fordham, N. Y. (*b*)	1869	Combined.
32	West Virginia Schools for the Deaf and the Blind	Romney, Hampshire Co., W. Va	1870	Combined.
33	Mystic Oral School for the Deaf	Mystic, Conn	1870	Oral.
34	Oregon School for Deaf-Mutes	Salem, Oregon	1870	Combined.
35	Maryland School for the Colored Blind and Deaf	Baltimore, Md. (649 W. Saratoga St.)	1872	Combined.
36	Colorado School for the Deaf and the Blind	Colorado Springs, El Paso Co., Colo.	1884	Combined.
37	Central New York Institution for Deaf-Mutes	Rome, Oneida Co., N. Y	1875	Combined.
38	Western Pennsylvania Institution for the Instruction of the Deaf and Dumb	Edgewood Park, Allegheny Co., Pa	1876	Combined.
39	Western New York Institution for Deaf-Mutes	Rochester, N. Y. (945 N. St. Paul St.)	1876	Man. alph.
40	Maine School for the Deaf	Portland, Me. (79–85 Spring St.)	1876	Combined.
41	Rhode Island Institute for the Deaf	Providence, R. I. (184 East Ave.)	1876	Oral.
42	New England Industrial School for Deaf-Mutes	Beverly, Mass	1879	Combined.
43	South Dakota School for Deaf-Mutes	Sioux Falls, Minnehaha Co., S. Dak	1880	Combined.
44	Pennsylvania Oral School for the Deaf	Scranton, Pa	1883	Oral.
45	New Jersey School for the Deaf	Trenton, N. J	1883	Combined.
46	Utah State School for the Deaf and Dumb	Ogden, Utah	1884	Combined.
47	Northern New York Institution for Deaf-Mutes	Malone, Franklin Co., N. Y	1884	Combined.
48	Florida State School for the Blind and the Deaf	St. Augustine, Fla	1885	Combined.
49	New Mexico Asylum for the Deaf and the Dumb	Santa Fé, N. M	1885	Manual.
50	Washington School for Defective Youth	Vancouver, Wash	1886	Combined.

A.—Public Schools (not Including Day Schools).—*Continued.*

	Name.	Location.	Date of opening.	Methods of instruction.
51	Deaf, Dumb, and Blind Institute for Colored Youth	Austin, Tex	1887	Manual.
52	Albany Home School for the Oral Instruction of the Deaf	Pine Hills, Albany, N. Y	1889	Oral.
53	Deaf and Dumb Asylum (of North Dakota)	Devils Lake, Ramsey Co., N. Dak	1890	Combined.
54	Home for the Training in Speech of Deaf Children before they are of School Age	Philadelphia, Pa. (*c*)	1892	Oral.
55	Montana School for Deaf and Blind	Boulder, Mont	1894	Combined.
56	North Carolina School for the Deaf and Dumb	Morganton, Burke Co., N. C	1894	Combined.
57	Oklahoma Institute for the Deaf and Dumb	Guthrie, Oklahoma	1898	Manual.

(*a*) Washington Heights, 163d Street and Broadway. (*b*) This institution has three branches; one situated at Westchester, another at Fordham (772 East 188th Street), and another at Brooklyn (113 Buffalo Avenue). (*c*) Belmont Avenue, corner Monument Avenue.

B.—Public Day Schools.

	Name.	Location.	Date of opening.	Methods of instruction.
1	Horace Mann School for the Deaf	Boston, Mass. (178 Newbury St.)	1869	Oral.
2	Wicker Park Public Day School for the Deaf	Chicago, Ill. Evergreen Ave. near Robey St.	(*e*)	Combined.
3	Hartigan Public Day School for the Deaf	Armour Ave. near 41st St.	1879	Combined.
4	Prescott Public Day School for the Deaf	Wrightward and Ashland Aves.	1879	Combined.
5	Monroe Street Public Day School for the Deaf	157 Monroe St.	1875	Combined.
6	Yale Public Day School for the Deaf	Corner 70th St. and Yale Ave.	1896	Oral.
7	Lyman Trumbull Public Day School for the Deaf	Corner Sedgwick and Division Sts	1896	Oral.
8	Kozminski Public Day School for the Deaf	Corner 54th St. and Ingleside Ave.	1896	Oral.
9	Seward Public Day School for the Deaf	4634 Ashland Ave	1897	Oral.
10	Darwin Public Day School for the Deaf	Hum. Blvd. and Armitage Ave	1898	Oral.
11	Burr Public Day School for the Deaf	Ashland Av. near North Ave	1898	Oral.
12	Froebel Public Day School for the Deaf	21st St. near Robey St.	1898	Oral.
13	Cincinnati Public School for the Deaf	Cincinnati, Ohio (719 W. Sixth St.)	1875	Manual.
14	St. Louis Day School for the Deaf	St. Louis, Mo. (*a*)	1878	Combined.
15	Milwaukee Public Day School for the Deaf	Milwaukee, Wis. (*b*)	1883	Oral.
16	Oral School of Cincinnati	Cincinnati, Ohio (719 West 6th St.)	1886	Oral.
17	Evansville Day School for the Deaf	Evansville, Ind. (High School Building)	1886	Combined.
18	Wausau Day School for the Deaf	Wausau, Wis	1890	Oral.
19	Cleveland Day School for the Deaf	Cleveland, Ohio (*c*)	1892	Oral.
20	Manitowoc Day School for the Deaf	Manitowoc, Wis	1893	Oral.
21	Sheboygan Day School for the Deaf	Sheboygan, Wis	1894	Oral.
22	Detroit Day School for the Deaf	Detroit, Mich. (*d*)	1894	Oral.
23	Eau Claire Day School for the Deaf	Eau Claire, Wis	1895	Oral.
24	Fond du Lac School for the Deaf	Fond du Lac, Wis	1895	Oral.
25	Marinette School for the Deaf	Marinette, Wis. (1532 Main St.)	1895	Oral.
26	Oshkosh School for the Deaf	Oshkosh, Wis. (Library building)	1895	Oral.
27	Appleton School for the Deaf	Appleton, Wis	1896	Oral.
28	Green Bay Day School for the Deaf	Green Bay, Wis	1898	Oral.
29	Black River Falls School for the Deaf	Black River Falls, Wis	1897	Oral.
30	Superior Day School for the Deaf	West Superior, Wis	1897	Oral.
31	Neillsville Day School for the Deaf	Neillsville, Wis	1899	Oral.
32	Los Angeles Oral School for the Deaf	Los Angeles, Cal	1898	Oral.
33	Loraine County Oral Deaf School	Elyria, Lorain Co., Ohio	1898	Oral.
34	Ashland Day School for the Deaf	Ashland, Wis	1898	Oral.
35	Stevens Point Day School for the Deaf	Stevens Point, Wis	1898	Oral.
36	Streator Day School for the Deaf	Streator, Ill	1898	Oral.
37	La Crosse Day School for the Deaf	La Crosse, Wis	1899	Combined.
38	Dayton School for the Deaf	Dayton, Ohio (corner Brown and Hess Sts.)	1899	Oral.
39	Derinda School for the Deaf	Derinda, Ill	1899	Oral.
40	Oakland Oral Day School for the Deaf	Oakland, Cal. (11th and Jefferson Sts.)	1899	Oral.
41	Sparta Day School for the Deaf	Sparta, Wis	1899	Oral.
42	Grand Rapids Day School for the Deaf	Grand Rapids, Mich	1899	Oral.
43	Muskegon Day School for the Deaf	Muskegon, Mich	1900	Oral.
44	Menominee Day School for the Deaf	Menominee, Mich	1900	Oral.

(*a*) Corner Ninth and Wash streets. (*b*) Corner Seventh and Prairie streets. (*c*) 1304 Willson Avenue. (*d*) Wilkins School Porter Street. (*e*) The first Public Day School for the Deaf in Chicago was opened in 1875 in a rented building on Van Buren Street.

C.—Denominational and Private Schools.

	Name.	Location.	Date of opening.	Methods of instruction.
1	German Evangelical Lutheran Deaf and Dumb School	North Detroit, Wayne Co., Mich	1873	Combined.
2	St. John's Catholic Deaf-Mute Institute	St. Francis, Wis	1876	Combined.
3	F. Knapp's Institute	Baltimore, Md. (851 and 853 Hollins St.)	1877	Oral.
4	The McCowen Oral School for Young Deaf Children	Chicago, Ill. (6550 Yale Ave.)	1883	Oral.
5	Ephpheta School for the Deaf	Chicago, Ill. (409 S. May St.)	1884	Combined.
6	Mariæ Consilia School for the Deaf	St. Louis, Mo. (1849 Cass Ave.)	1885	Combined.
7	Sarah Fuller Home for Little Children Who Cannot Hear	West Medford, Mass. (93 Woburn St.)	1888	Oral.
8	Notre Dame School for the Deaf	Cincinnati, Ohio (*a*)	1890	Combined.
9	Deaf-Mute Institute of the Holy Rosary	Chinchuba, St. Tammany Parish, La	1890	Combined.
10	St. Joseph's Deaf-Mute Institute for Boys	Longwood Place, South St. Louis, Mo.	1892	Combined.
11	Wright-Humason School	New York, N. Y. (42 West 76th St.)	1894	Oral.
12	St. Joseph's School and Home for Deaf-Mutes	North Temescal, Cal.	1895	Combined.
13	St. Francis Xavier's School for the Deaf	Baltimore, Md. (903 McColloh St.)	1897	Combined.
14	Boston School for the Deaf	Jamaica Plain, Mass. (9–11 St. Joseph St.)	1899	Oral.

(*a*) Sixth Street, between Sycamore and Broadway.

School Age.—There is a difference of opinion among experienced teachers as to the best age for sending deaf children to school. On the one hand, such children have so much to learn as compared with hearing children that their education ought to be begun as early as possible; on the other, there are obvious objections to taking them away from their homes—as in the great majority of cases is necessary in order that they may receive proper instruction—while they are still very young. The decision must depend largely upon the circumstances of the individual, and the facilities offered by the State in which he resides. Where the term of instruction afforded by the State is limited to six or seven years, and where children are surrounded by favorable influences at home, probably ten or twelve is the best age for them to be sent to school, since experience has shown that the six or seven years following that age are those in which the most can be accomplished for the physical, mental, and moral development of the deaf-mute; but where, as is the case in some States, there is no limit to the term of instruction, where proper provision is made for the care and teaching of the little children by kindergarten methods apart from the older pupils, and especially where the home influences are bad, it is desirable to send them as young as six years of age. From six to ten they will make less progress at school than from ten to fourteen; but if, in addition to those four years under ten, they remain six or seven years longer, they will be able to acquire a much fuller mastery of the language of their fellow-men, and to reach a far more advanced stage of education in all respects, than if their education had not been begun until the years of early childhood were passed.

Boarding Schools and Day Schools.—Within recent years laws have been passed in several States providing for the establishment of day schools for the deaf, the town or city desiring such a school providing the necessary room or rooms and the State paying a certain sum *per capita* for the children taught. This has the advantage of enabling the pupils to live at home while receiving instruction, but experience has shown that the education thus given is less efficient and successful than in boarding schools. The evil influences that surround many deaf children at home, the temptations of the street out of school hours, the danger of accidents in going to and from school, the interruptions to progress from tardiness and absence, and the lack of facilities for industrial instruction, make the results much less satisfactory than in the well-organized boarding school, where the influences of the workshop, the playground, and the evening study hour, all combine with those of the school room to promote the proper development and education of the child.

Private Instruction at Home.—It has been said that "the best deaf-mute school is a school of one pupil," but the statement is not to be received without some qualification. In order to attain a mastery of spoken or written language the more individual attention the deaf child receives the better, and in this respect private instruction at home has a decided advantage over class instruction at school. On the other hand, the child taught alone at home, and thus lacking the stimulus of association with others placed on an equal footing with himself, is apt to become listless in study and melancholy in disposition. The best advice, therefore, to be given to parents whose means enable them to provide a private teacher is this: Obtain a competent tutor or governess for your child at three or four years of age. Let the efforts of this teacher for seven or eight years be devoted almost wholly to giving the child language, articulation, and speech-reading by the natural intuitional method, which imitates as closely as the nature of the case allows the manner in which hearing children learn to speak, and let the teacher's efforts be heartily seconded by all the other members of the family. When the child is ten or twelve years old send him to school to pursue other branches of study and complete his education. The command of idiomatic language acquired by the home training is something that could not be imparted at school, while the moral and intellectual development received at school could not be attained at home.

Intelligent parents and friends, whose pecuniary circumstances do not allow them to employ a private teacher, can themselves do a great deal in the way of preparing their deaf children for school life by forming in them habits of order and obedience, and by teaching them the use of the pencil and pen, counting, and common words in their written forms. If the child already possesses speech gained before hearing was lost, great efforts should be made to retain the speech and to cultivate the habit of reading the speech of others. If any hearing exists, it should be utilized in practice, the aid of the hearing tube, trumpet, and akouphone should be tried, and whichever instrument proves most effective should be employed. In all cases the deaf child should be governed with the same firmness as his hearing brothers and sisters. While due allowance should be made for his inability to understand, and he should be protected as far as possible from the teasing of playmates, he can and should be taught strict obedience to parents, and due respect for the rights of others.

Higher Education.—The standard of education in schools for deaf-mutes at the present day corresponds in general to that of the common schools—an education fitting the pupil for intelligent citizenship. But there are some among the deaf who are capable of advancing beyond this standard and preparing themselves for scientific and literary pursuits. The United States makes provisions for the wants of this class in Gallaudet College, established by Congress at Washington, D. C., in the year 1864, through the efforts of Edward M. Gallaudet, Ph.D., LL.D., who has been its president from the beginning. This college affords a course of training corresponding to that of American colleges in general, with such modifications as seem desirable in view of the peculiar needs of the deaf, and confers upon its graduates the usual academic degrees. Of the students who have been connected with the college a large number are now engaged in teaching, several are editors and publishers, others are in the civil service of the Government, one is a lawyer practising in the Supreme Court of the United States, one is at the head of large assaying works in Chicago, several are clergymen preaching to the deaf, and nearly all are occupying positions of a higher grade than would have been possible without the educational advantages conferred by the college course.

Religious Work for Adults.—The moral and religious instruction given in most of the American schools for the deaf is of an unsectarian character, the pupils being advised by their teachers to connect themselves during their vacations, or after leaving the schools, with the churches to which their parents belong. Adult deaf-mutes, however, can derive much more pleasure and profit from special services in the sign language than from ordinary religious exercises, and in places where their numbers are sufficiently large to form a congregation, the holding of such services is entirely practicable. The Rev. Thomas Gallaudet, D.D., of New York, established a church for deaf-mutes in that city in 1852, and through his efforts and those of other friends of the deaf, arrangements are now made by which religious services in the sign language are held weekly in several cities of the United States, and at less frequent intervals in many other places. The Episcopal Church, with which Dr. Gallaudet is connected, has been by far the most active in providing for the religious welfare of adult deaf-mutes, but other churches have also had a part in the work. There are now several ordained clergymen in the United States who are themselves deaf, and there are a large number of deaf laymen who assist in missionary work. In connection with the religious organizations there usually exist benevolent and relief societies, and in some cases literary and social unions. *Edward Allen Fay.*

DEAF-MUTES: The Language of Signs, and the Combined System of Instructing Deaf-mutes.

I. The Language of Signs.—The French philosopher

Condillac begins his treatise, "Grammaire générale et raisonnée," as follows: "The means of which men first made use to communicate their thoughts were gestures, movements of the countenance, and inarticulate sounds. The combination of these may be called *the language of action.*" This view of Condillac's as to the origin of language may have "no sufficient support from observed facts," as the distinguished English anthropologist Edward B. Tylor asserts; but it may certainly be accepted as a plausible hypothesis, for the overthrow of which no "observed facts" can be adduced. It is, however, foreign to the purpose of this article to inquire what was the primitive language. The aim will be to show that there is a true language of gestures; that it is as natural and may be as complete a vehicle of expression as speech; that this language has great utility among people who hear; that in the humane and scientific education of the deaf it is indispensable; that its judicious use by deaf-mutes is a source of great benefit and pleasure during the entire period of their lives; and that among this interesting and intelligent class of the community nothing can be found that will take its place.

That there is a true language of signs, history gives abundant evidence. Quintilian, the Roman orator and teacher of rhetoric in the first century of our era, says: "Amidst the great diversity of tongues pervading all nations and people, the language of the hands appears to be common to all men." In the days of Quintilian the language of signs was an important feature in public amusements, the mimics or pantomimists of the time of Augustus carrying the art to the highest degree of perfection. The famous actors Pylades and Bathyllus expressed in mimic language the greatest variety of scenes and incidents, including even the history of illustrious men. Amusements of this character were maintained for more than five centuries, when they had become so gross and indecent that Charlemagne put a stop to them in the name of morality.

The language of gestures has been employed in very many instances by persons of widely differing nationality and race, and utter strangers to each other up to the moment of resorting to this means of communication. At the time when the Amistad Africans were in prison in Hartford, Conn., awaiting their trial before the United States District Court, a visit was paid to them by the Rev. T. H. Gallaudet, then principal of the Institution for Deaf-mutes in that city. Having no means of communicating orally with these negroes, Dr. Gallaudet found no difficulty in carrying on conversation with them by means of expressive action, which elicited various information respecting the families they had left in Africa, besides some particulars of their own recent history; all of which they imparted with the peculiar pleasure resulting from this unexpected facility of communication with a stranger.

To how great an extent the sign language has served as a means of communication among the aborigines of America is shown by Col. Garrick Mallery, U. S. A., in his admirable monograph on "Sign Language among North American Indians compared with that among Other Peoples and Deaf-mutes," published by the Government of the United States, under the auspices of the Bureau of Ethnology of the Smithsonian Institution.

Enough has been said to show that there is a true language of signs, and that it has been of great use among people who hear. But to discover the field of its greatest utility, and to find it in its fullest development as a vehicle of expression, one must become informed as to the service it performs in the intellectual and social life of the deaf.

A few isolated instances are recorded, previous to the last century, of deaf persons who, under favorable conditions, have developed for their own use a measurably complete language of signs. But it was only toward the middle of the eighteenth century that this language was used by considerable numbers of deaf-mutes. Before describing this general use, however, it is important to consider, somewhat carefully, the limitations as to means of communication which absolute deafness imposes on those who suffer from it.

The means of expression possible to creatures of intelligence, by which information as to thought and feeling may be given and received, are five in number, corresponding to the senses. All expression—*i.e.*, all communication from one intelligent being to another—must, therefore, be either audible, visible, tactile, odoric, or palatal. The senses of taste and smell are addressed so rarely and with such difficulty, for the purpose of communicating thought, that they may be left out of view. The same may be said of the sense of touch, except that, in the case of persons both blind and deaf, it becomes the main channel of communication, and may be made useful under certain conditions with such as are only deaf; as, for example, in the dark, or when it is desirable to address the deaf without diverting the eye from some object—such as a landscape, a passing pageant, or spectacle.

Visible expression employs a great variety of forms in the accomplishment of its purpose, but these forms may be grouped in two perfectly distinct classes: the *gestural*, which produce their effects only from moment to moment, having no enduring quality, and the *graphic*, which are more or less permanent.

Audible expression, almost infinite as it is in variety, is susceptible also of division into two great classes, *articulate* and *inarticulate*, the former comprising all forms of word utterance, and the latter including cries, moans, sighs, music, percussions, and explosions.

Among all these possible means of transmitting intelligence from one to another, it will readily be seen that the three principal means of communicating thought and feeling made use of by man are: (1) *Articulate speech*, addressed to the sense of hearing; (2) *gestural;* and (3) *graphic expression*, presented to the sense of sight.

By gestural expression must be understood all positions and movements of the body or any of its members, including the countenance, and all noiseless signals such as are made use of in military or engineering operations, on the sea, on roads, or on rivers; in short, all devices for communicating information through the eye of man, which are not in any manner recorded or made permanent.

Graphic expression will then include all forms of writing and printing, all productions in the fine arts, all marks of whatever character that are in any degree permanent, and are designed to communicate information or to express thought and feeling. And the range of this form of expression is wide enough to embrace at one extreme the Duomo of Milan, or Milton's noblest poem, and at the other the cattle brand of a Texan cowboy, or the blaze of a backwoodsman's axe in the primeval forest.

In determining the value of gestural expression to the deaf, it is necessary to keep constantly before the mind the fact that, where hearing does not exist, no mental impressions can be received through the means of articulate speech. In other words, that he who would communicate with the deaf is limited to gestural and graphic means. Even in cases in which a deaf person retains the power of speech, or is taught to speak and to understand the speech of others by watching the motion of the lips, such motions are to him nothing other than a certain form of gestural expression. The peculiar element of sound, the perception and understanding of which enable a hearing person to comprehend speech *without* seeing the vocal organs of the speaker, is wholly wanting to the deaf. And so essential is the possession of hearing to the free use and enjoyment of articulate speech as a means of communication from man to man, that to the deaf this can be no more, at its very best, than what an artificial leg is to one who would walk, or run, or dance. Serviceable, no doubt; far better than no leg at all, but never an equivalent for the missing member.

Have the deaf, then, no means of expression that can be as free and as perfect as speech is to their more favored brethren?

A distinguished scientist and philanthropist, justly honored and respected in the city of his adoption (Washington, D. C.), who has long been interested in the education of deaf-mutes, but who has had little experience in teaching them, has said before one of the learned societies of Washington:

"Nature has been kind to the deaf child; man, cruel. Nature has inflicted upon the deaf child but one defect, imperfect hearing; man's neglect has made him dumb and forced him to invent a language which has separated him from the hearing world." "Let us then," says the learned writer, "remove the afflictions that we ourselves have caused." And after some eminently reasonable sugestions he adds: "And last, but not least, let us banish the sign language from our schools."

Nature has indeed been kind to the deaf child, in that she has left him capable of using as freely as his hearing brother the gestural and the graphic means of communicating thought; in that she has made it natural and easy for him to employ a method of expression in the use of which he is at no disadvantage as compared with his hearing brother, and which is beyond all dispute the *only* means of communication which can be to the deaf what speech is to the hearing as a vehicle of thought. And this "language of action," which philologists agree is the foundation of all human intercommunication, which is the acknowledged vernacular of the deaf, the distinguished theorist, and not a few others with him, would "banish from our schools." Of such an act of "kindness" proposed by certain teachers of the deaf on both sides of the Atlantic, one of the most eminent and successful oral teachers of deaf-mutes in Germany says: "If this system were put into execution, the moral life, the intellectual development of the deaf and dumb would be inhumanly hampered."

The founder of deaf-mute instruction in America, who is to be ranked among the most successful teachers of the deaf in the world, says in an article on "The Natural Language of Signs," written some years after he had completed his work for the deaf, and when he had had time to review his methods with calmness:

"My object is to show the intrinsic value and, indeed, indispensable necessity of the use of natural signs in the education of the deaf and dumb. . . . In attempting this, I wish I had time to go somewhat at length into the genius of this natural language of signs; to compare it with merely oral language, and to show, as I think I could, its decided superiority over the latter, so far as respects its peculiar adaptation to the mind of childhood and early youth.

"In what relates to the expression of passion and emotion, and of all the finer and stronger sentiments of the heart, this language is eminently appropriate and copious.

"So far as objects, motions, or actions addressed to the senses are concerned, this language, in its improved state, is superior in its accuracy and force of delineation to that in which words spelt on the fingers, spoken, written, or printed are employed."

This claim of the superior accuracy and precision of sign language, as compared with words, may perhaps excite surprise at first thought. But it is believed that its reasonableness will appear when it is remembered that the meanings attached to words are almost wholly arbitrary, very few giving the slightest hint of their signification in their shape or sound; while nearly every gesture used in sign language carries with it a plain suggestion of its meaning, and in very many instances gives a vivid and easily recognized portrayal of the idea to be conveyed.

Since experience has proved that sign language is natural to the deaf, that it is acquired and made use of by them more easily than speech is by the hearing, that it furnishes a full and adequate means for communicating thought and feeling, often surpassing speech in vividness and exactness, it is not strange that teachers of the largest experience and broadest view unite in approving its use in the education of the deaf.

At this point the question will naturally arise in many minds: "Does the sign language give the deaf in these respects *all* that speech affords to the hearing?"

The experience and observation of the writer lead him to answer the question with a decided affirmative. On many occasions it has been his privilege to interpret through signs to the deaf, addresses given in speech; he has addressed assemblages of deaf persons many times using signs for the original expression of thought; he has seen hundreds of lectures and public debates given originally in signs; he has seen conventions of deaf-mutes in which no word was spoken, and yet all the forms of parliamentary proceedings were observed, and the most excited and earnest discussions carried on; he has seen the ordinances of religion administered, and the full services of the church carried on in signs; and all this with the assurance growing out of his own complete understanding of the language, a knowledge of which dates back to his earliest childhood, that for all the purposes above enumerated gestural expression is in no respect inferior, and is in many respects superior, to articulate speech as a means of communicating ideas.

But the greatest value of the sign language to the deaf, when the whole period of their lives is taken into account, is to be found in the facility it affords for free and unconstrained social intercourse. And in this, as in the matter of public addresses, nothing has been discovered that *can* fully take its place.

Graduates of schools, from which the attempt has been made to "banish signs," have repeatedly testified that they could in no way attain to such pleasure in social intercourse as through the use of sign language, ability to employ which they readily acquire by mingling with those more favored deaf-mutes who have become familiar with it earlier in life.

"But," say those who urge that the use of signs is an injury to the deaf, "they can use that language only with their fellow-unfortunates, or with the very few others who learn it for their sake, and their use of signs tends to make them clannish, thus narrowing the sphere of their lives, and leading them to employ in excess a language other than the vernacular of their country."

It is admitted that, in the education of the deaf, injudicious teachers may allow, or even encourage, too free a use of the sign language in the schools,—that such teachers may suffer their pupils to go out from under their influence without being impressed with the importance of making special and persistent efforts to overcome the *tendency* to clannishness which is natural to the deaf, no matter what method of instruction is employed.

It is not disputed that in teaching the deaf, signs may be so employed as to affect unfavorably the acquisition by the pupil of verbal language, whether in its written or spoken forms.

But nothing is more certain, as proven by the experience of nearly three-fourths of a century in this country, than that the unfavorable results which some have charged upon the use of the sign language, are attributable in all cases to its *abuse* by injudicious, incompetent, or inexperienced teachers. Since 1817, when the first permanent school for deaf-mutes in this country was established, more than forty thousand children have been educated in a hundred schools now in successful operation, in all of which the sign language has been made use of. A majority of these persons are living to-day, and some of them may be found in every city, probably in every county of the land.

Among these, thousands could be named who, while associating freely with their fellow deaf-mutes, and deriving both profit and pleasure from such association, mingle readily with persons who hear; who are not clannish to any degree that would subject them to just criticism; who use the vernacular of the country with freedom and reasonable accuracy; who maintain themselves reputably and comfortably by their own labor; who are, in short, good and intelligent citizens, adding strength, wealth, and character to the communities in which they reside.

II. THE COMBINED SYSTEM OF INSTRUCTING DEAF-MUTES.—It is a matter of singular coincidence that schools for the deaf should have been first established in the three leading nations of Europe at about the same period, and as the result of entirely independent effort. This occurred very near the middle of the last century.

The Abbé de l'Épée inaugurated in France what will be presently described as the manual method. Samuel Heinicke was the founder in Germany, as Thomas Braidwood was in Great Britain, of the oral method.

The promoters of these two methods were each earnest in urging the superiority of his own over the other, and for a full century the deaf-mute schools of the world were either manual or oral, with little thought in the mind of any one that there might be found a golden mean between the two extremes. Within the past twenty years, however, it has been proved possible, by many teachers of no little prominence in Europe and America, to appropriate the elements of greatest value in the two methods so long in conflict, and to secure, under what has been termed the combined system, all that is of advantage in the education of the deaf.

With such favor have the claims of the combined system been received in this country that on December 1st last (1899), out of 57 public institutions existing in the United States, 45 were being conducted in accordance with this system, as against 7 oral and 5 manual schools. In the 45 combined schools there were 9,863 pupils; in the 7 oral schools 685 pupils, and in the 5 manual schools 212 pupils. During the last ten years the number of pupils in the public oral schools has diminished, while there has been an increase of 40 per cent. in the number of pupils in the public combined schools.

The principal considerations which commend this system may be presented in a few words.

The experience of a century and a half of practical instruction of the deaf has established no conclusion more clearly than that it is impossible to teach all deaf-mutes to speak. Some are found to be lacking more or less in mental capacity; some have only a weak and inefficient imitative faculty; with others an infirmity of vision is discovered; others again have little quickness of tactile perception. And it is far from being true, as the eminent scientist to whom reference has been made has affirmed, that "nature has inflicted upon the deaf child but one defect—imperfect hearing."

In former times these doubly or trebly defective children were summarily dismissed from oral schools, with the unjust and inhuman condemnation that they were imbeciles. And even at the present they are often quietly dropped from such schools under one pretext or another, because the oral teachers are perfectly well aware that they cannot be educated under their method.

The essential defect in the oral method is, then, that it practically rejects a large proportion of the deaf as incapable of education,—that it fails with those who stand in greatest need of a helping hand.

The radical deficiency of the manual method is that it makes no provision for imparting the extremely valuable accomplishments of articulation and lip-reading to the large percentage of the deaf that is certainly capable of acquiring these great gifts.

The doors of the combined-system schools are wide open to *all* the deaf—to the weaker as well as to those more richly endowed with capacity for improvement. In these schools no method or appliance is rejected that can be shown to be of practical help to any number, however small, of the great class of the deaf.

The achievement of imparting speech to one who has it not comes so near to being a miracle that one is dazzled by the brilliancy of the triumph, and is apt to feel that everything else in the education of the deaf must be subservient to this. Parents and friends of the deaf need to be placed on their guard against this grave error, and to be advised that those schools and systems best deserve their confidence and support that seek to give the broadest and most valuable education possible to *all* the deaf.

Within the past decade the educated deaf-mutes in Europe and America have been demanding the general adoption of a combined system in schools for their class. This attitude on their part is, perhaps, most noteworthy in Germany, for in that country the oral method has been practised almost exclusively since the establishment of the first school for deaf-mutes more than a century and a half ago.

A petition signed by more than eight hundred deaf-mutes, all graduates of oral schools, was presented to the Government, setting forth the insufficiency of the oral method in many cases, and praying that a combined system might be generally introduced.

Many conventions of educated deaf-mutes in Europe and America have adopted, unanimously, resolutions strongly approving the combined system, but the most notable of these gatherings was one in Paris in August, 1900. The French Government invited the deaf-mutes of the world, with their hearing friends and teachers, to join in a "congress for the study of questions of education and assistance of deaf-mutes." This invitation was accepted by about two hundred deaf-mutes and one hundred hearing persons. The deliberations of the congress were carried on in two sections, each adopting resolutions as to methods of instruction. The hearing section voted in favor of the pure oral method, with opposing votes from the Swedish, Danish, German, Swiss, and American delegates.

The section of deaf-mutes voted unanimously in favor of a combined system. A large majority of the leaders among these deaf-mutes had been educated in pure oral schools. Nearly all these men are personally known to the writer of this article, who attended the Paris congress.

These orally educated deaf-mutes are men of much more than ordinary intelligence, and their testimony as to the insufficiency of the method under which they were educated should be given the greatest possible weight.

Edward M. Gallaudet.

DEAFNESS.—As blindness is the result of an alteration in any of the media through which light is transmitted, so deafness is the result of an abnormal change in the condition of any of the media through which sound is conducted.

What deafness is may be best understood when we comprehend what hearing is. To understand the philosophy of hearing, the converse of which is deafness, it is necessary first to consider the organ, or the machinery, by means of which hearing is effected. The auditory apparatus, exclusive of the sensorium, presents a series of agencies for the reception, conduction, and perception of the sonorous vibrations, which agencies stand in such nice relation to each other that if the function performed by one be interrupted, the operation of the whole is at once suspended.

The auricle concentrates the sound waves and directs them to the external auditory canal which, by reason of its peculiar conformation and the contained air, serves both to intensify the force of the sound waves and to regulate their impact against the drumhead. The impulsion thus received is conveyed to the foot plate of the stirrup (in the oval window) through the intervening ossicula auditus which span the cavum tympani. This impression, transmitted now to the labyrinth, operates in turn upon the labyrinthine fluid which delivers the oscillation to the expansion of the auditory nerve in the cochlea. Thus, we discover that the organ of hearing consists of an apparatus for the reception or collection of sound waves, another for their conduction, and a third which determines their final disposition, constituting the natural divisions of an *external*, a *middle*, and an *internal* ear.

Deafness, then, may be defined to be an interference with the auditory function in any of the three parts which are essential to its performance. The interference may lie at the periphery, or it may exist centrally. It may be consequent upon mechanical obstruction or referable to pathological changes.

An essential condition to normal hearing, and the one most liable to derangement, is a vibratile drumhead. This presupposes an unobstructed external canal and a pervious Eustachian tube, as an equal pressure of air on both sides of the membrane and an unaltered structure are indispensable to its vibratory function.

The diseases which most commonly impair the efficiency of the membrana tympani, and so affect the hearing, are those which have their origin in colds and are denominated catarrhal. These disorders, affecting first the naso-pharyngeal mucous membrane, find in the pharyngeal mouth of the Eustachian tube a point of entry to the ear. When the inflammation is limited to the tube the simplest form of deafness results, the degree of deafness being proportional to the intensity of the inflammatory process and the consequent interference with the air supply to the middle ear. The extension of inflammation to the middle ear constitutes an otitis media catarrhalis (non-suppurative inflammation—Roosa). In the acute form this disease may be treated as successfully as acute inflammation, affecting other organs of the body, is treated. Neglect in the early stage permits the disease to become chronic and leads to tissue change, the treatment of which meets with success corresponding to that realized in the treatment of similar conditions in other parts of the body. Compared with other forms of ear disease the relative frequency of this is as one to two and a half.

The next most frequent cause of deafness is found in the suppurative inflammation of the middle ear (otitis media purulenta acuta et chronica), which also has its origin in the pharynx or results as a sequel to rhinitis. The coryza of the exanthemata very commonly has this termination. In view of the destructive character of the process, and considering the anatomical peculiarities of the middle ear and its relations, the gravity of this affection cannot well be overestimated. Its ravages are not always confined to the parts which are primarily involved, but may invade the mastoid antrum, or by secondary invasion give rise to caries, pyæmic disturbance, cerebral abscess, and death.

The following table indicates how much more frequently the cause of deafness is found to be located in the middle ear than in the external ear or the labyrinth:

Reporter.	Number of cases.	External ear.	Middle ear.	Internal ear.
Blake	1,652	466	1,128	58
Burnett	1,187	279	868	40
Spencer	1,263	243	978	42

It is thus seen that the ear affections which have their origin in inflammations of the naso-pharyngeal mucous membrane constitute the vast majority of all the diseases of the ear. This is of the greatest significance. It should lead to a more careful study of the diseases of the nose.

As would be naturally inferred, the constitutional treatment becomes also a very important factor in the treatment of deafness having this origin.

The interferences with the hearing that may exist in the external auditory canal are briefly best classified into mechanical obstructions, and those which arise from inflammatory action. Under the former class are to be placed foreign bodies, accumulations of cerumen, exostoses, and obstructive deformities; under the latter the inflammatory diseases of the meatus.

Diseases of the internal ear are rare. They are of primary or secondary inflammatory nature. Structural changes may be induced as a consequence of tympanic disorders, or they may result from the effect of toxic diseases or arterial disturbances.

Deafness may be unilateral or bilateral. Circumstances of exposure or individual habit or accident determine the diseased process to one side or to both. This must be the explanation, as is claimed by some writers, if one ear is found to be affected more frequently than the other.

For determining the extent to which the hearing is impaired, the voice, in pronunciation of vowel sounds, and the watch are the most reliable tests. For detecting whether aerial conduction is obstructed the tuning-fork may be employed. The vibration of the fork being communicated through the tissues of the head, the affected ear will be the one which is sensitive to the sound.

The greater liability of children to those diseases of the ear which give rise to high degrees of deafness, and which render them liable to deaf-mutism, appeals urgently to the medical profession for a more general and accurate knowledge of this subject. Deaf-mutes are dumb for the reason that, being deprived of hearing, they are incapacitated for the acquisition of language. The causes of acquired deafness exist largely in such diseases as smallpox, measles, typhus, convulsions, paralysis, hydrocephalus and other affections of the brain, and scarlatina, which more frequently than any other disease leaves the patient deaf. Hereditary transmission may be cited as another cause of deafness. Acquired deafness which is of such a degree as to lead to dumbness stands in relation to congenital deafness as forty per centum to sixty per centum.

H. N. Spencer.

DEARBORN SPRING.—Windsor County, Vermont.
Post-Office.—Woodstock.

This spring, formerly known as the "Old Sanderson Spring," is located in Woodstock about three miles from the famous Woodstock Inn. A fine level road leads to within three-quarters of a mile of the spring, a good hill road covering the remainder of the distance. The spring was discovered about 1830, and soon gained a considerable reputation among the neighboring farmers for its good effects in dyspepsia and skin diseases. The water was analyzed about 1850 by one of the professors in the Woodstock Medical School. The analysis has been lost, but it is said that, among other ingredients, magnesia, iron, and sulphur were found. It is said to resemble the Poland Springs water of Maine. In 1890 the springs passed into new hands, and the owner had it excavated to the bed-rock, thoroughly cleaned and stoned up to within four feet of the surface, and then tiled and carefully protected from the surface water. The tiling was extended upward through a tight floor and a building erected over the spring, with easy facilities for raising the water. The location is now enclosed in a beautiful park, with avenues leading to the spring. Its elevation is 900 feet above Woodstock Park and about 1,600 feet above sea level. The atmosphere is pure and invigorating, and a number of fine views may be had from the park surrounding the spring. The water of the spring maintains an even temperature throughout the year, which fact would indicate that it proceeds from a great depth. It is icy cold when the temperature of the surrounding air stands at 90° F. in the shade.

James K. Crook.

DEATH CERTIFICATION.—The objects secured by a well-devised system of death certification are manifold and may be enumerated as follows:

1. Questions relating to property *rights* are often settled by a single reference to the record of a death.
2. The official certificate of a death is usually required in each case of claim for *life insurance.*
3. Death certificates settle many disputed questions in regard to *pensions.*
4. They are of great value in searching for records of *genealogy.*
5. A death certificate frequently furnishes valuable aid in the *detection of crime.*
6. And by no means the least in importance. Each individual certificate is a contribution *causa scientiæ.* Taken collectively they are of great importance to physicians, and especially to health officers, in the study of disease, since they furnish valuable information in regard to its causes, its prevalence, and its geographical distribution.

The following items should be recorded in each certificate, so far as it is possible to obtain them:

The name of the deceased; the date of birth; the date of death; the sex of the deceased; the age of the deceased.

The color of the deceased.

The occupation of the deceased.

The conjugal condition (single, widowed, married, or divorced).

The residence.

The place of birth.

The place of death.

The names and place of birth of the parents.

The disease or cause of death.

The place of burial.

To these it is customary to add in some countries the maiden name of the mother, and if the deceased was a married or divorced woman, or a widow, her maiden name, and that of her husband. In cities the name of the street and number should also be stated. It is also customary in some countries to state the sect or religious denomination of the deceased. It also increases the value of a certificate to state both primary and secondary causes of death when this is possible. The duration of the last illness is sometimes added.

Law Relating to Death Certification.—The provisions of the laws of different States and countries relative to death certificates are quite similar, the differences relating to minor points. That of England was enacted in 1836 and amended in 1874. Under the latter act, personal information of every death must be given to the registrar of the district, within five days of its occurrence, by the nearest relatives of the deceased, present at the death, or in attendance during the last illness. The penalty for neglect is 40*s*.

A registered medical practitioner during the last illness must give a certificate of the cause of death to the best of his knowledge and belief. He is liable to a penalty of 40*s*. for neglect, or £10, or imprisonment for giving a false certificate.

Deaths are also certified by coroners. No record is made of still-births in England, either as births or as deaths.

The indefinite character of the information secured by the laws relating to death certificates is due to several causes, namely, the carelessness and ignorance of the persons certifying, the absence of medical attendants during the last illness, and the indefinite character of the disease itself. In order to secure an improvement in existing conditions, a committee of the House of Commons was convened in 1893, and after listening to conclusive evidence made the following recommendations:

1. That in no case should a death be registered without production of a certificate of the cause of death signed by a registered medical practitioner or by a coroner after inquest, or in Scotland by a procurator fiscal.
2. That in each sanitary district a registered medical practitioner should be appointed as public medical certifier of the cause of death in cases in which a certificate from a medical practitioner in attendance is not forthcoming.
3. That a medical practitioner in attendance should be required, before giving a certificate of death, personally to inspect the body; but if, on the ground of distance or for other sufficient reason, he is unable to make this inspection himself, he should obtain and attach to the certificate of the cause of death a certificate signed by two persons, neighbors of the deceased, verifying the fact of death.
4. That medical practitioners should be required to send certificates of death to the registrar, instead of sending them to the representatives of the deceased.
5. That a form of a certificate of death should be prescribed, and that in giving a certificate a medical practitioner should be required to use such form.
6. That it should be a penal offence to bury or otherwise dispose of a body, except in time of epidemic, without an order from the registrar stating the place and mode of disposal, which order, after it has been acted upon, should be returned to the registrar who issued it.
7. That it should be made an offence to retain a dead body unburied or otherwise legally disposed of beyond a period not exceeding eight days, except by permission of a magistrate.
8. That the practice of burial in pits or common graves should be discontinued.
9. That still-births which have reached the stage of development of seven months should be registered upon the certificate of a registered medical practitioner, and that it should not be permitted to bury or otherwise dispose of the still-birth until an order for burial has been issued by the registrar.
10. That, subject always to the discretion of the Crown Office, the result of precognitions taken by procurators fiscal in Scotland, or the precognitions themselves, should be communicated to the representatives of the deceased when application is made for the same.*

In Austria the burial of a corpse before death is officially registered is forbidden. Deaths must be immediately notified to the authorities. Each commune nominates a *Beschauer* who must be either a physician or a surgeon, whose duty it is to examine whether the person is really dead, whether there is evidence of violent death, or whether death was caused by an infectious disease. If there is suspicion that the death is only apparent, measures must at once be taken to restore animation, and a certificate must not be given in such case till decomposition has begun. If the deceased has had medical care, the attending physician must make a certificate of death and send it to the registrar.

In Belgium no burial can take place before the death has been verified by a divisional physician, after a complete and careful examination of the body. This verification and the identification of the deceased must be certified in accordance with a given scheme. For those who die at birth, the certificate must state whether death occurred before, during, or after delivery, and in the latter case, how long the infant lived after its birth.

In Denmark every death is reported to the parish clerk, and to the clergyman of the parish where it occurred, and is included in the parish register, whether the deceased belonged to the parish or not. No burial can take place before a medical man, or an official qualified to inspect corpses, has issued a certificate.

The following items are called for by the death certificates of Berlin:

1. Full name, sex, and condition of deceased. If a child, the names and condition of the parents. If the mother has an occupation, it should be stated.
2. Residence of deceased. In what story, and whether in front or rear part of house. If in a public institution, the last residence of the deceased.
3. Age of deceased. Date of birth.
4. Day and hour of death.
5. Personal signature of physician or surgeon who had attended the deceased, or inspected the body.
6. Whether the deceased was personally known to the physician.
7. What certain signs of death were observed.
8. Disease or cause of death.
9. Whether any marks of violence were found on the body.
10. Whether the cause of death was an infectious disease.
11. Whether any, and what measures are advisable for preventing the spread of infection.
12. Whether measures for resuscitation were employed in any case when they were indicated.
13. Religious belief of deceased.
14. Remarks.† .

Certificates of death are now required by law in each of the New England States, in New York, New Jersey, Delaware, Michigan, Minnesota, and Indiana.

They are also required in nearly all, if not in all, of the large cities of the United States.

In several of the largest cities it is a common practice to issue blank certificates, bound in books of one hundred or more, for the use of physicians. Upon the cover is printed a set of instructions having reference to the subject of causes of death and the best methods of stating such causes.

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* Report of Select Committee on Death Certification (British Parliament), London, 1893.

† "Generalbericht über das Medizinal- und Sanitätswesen der Stadt Berlin."

In the State of Michigan special attention has been given in recent years to the subject of registration, and a decided advance has been made in the appointment of an intelligent physician whose duty it is to supervise the collection and publication of vital statistics throughout the State, and therefore to act in the capacity of a registrar-general for the State.

The following certificate of death has been recently adopted in Michigan, and is a very good model:

MARGIN RESERVED FOR BINDING.

☞ Write Plainly with Unfading Ink—This is a Permanent Record.

Place of death:
County ....
Township ....
Village ....
City ....

MICHIGAN
DEPARTMENT OF STATE
LANSING
VITAL STATISTICS DIVISION.

[The Registrar should number each certificate received *at once*, in space below, beginning with "No. 1" for each year.]

REGISTERED NO.
....

CERTIFICATE AND RECORD OF DEATH.

Location in city ....Ward; No........, ...St.

Full Name..Date of Death.

Month.	Day.	Year.
		1........

Hospital, institution or transient ....
How long an inmate or resident ....
Sex..................
Color..................
Late or home residence ....
Single, married, widowed or divorced ....

Age	Years.	Months.	Days.

If married, age at (first) marriage..............years.

Parent of...........children, of whom...........are living.

Date of birth.	Year of birth.	Month.	Day.
	1........		

Occupation, if over 10 years of age. ....
Birthplace (State or Country.) ....
Name of father) ....
Birthplace father (State (or Country) ....
Maiden name of mother ....
Birthplace of mother (State or Country ....
Date of burial or removal ....
Place of burial or removal ....
Signature of undertaker. ....
Address of undertaker ....

CERTIFICATE OF REPORTER.

The personal and family particulars herein given relative to deceased are true to the best of my knowledge and belief.

(Signed) ....
(Address)..................................

MEDICAL CERTIFICATE OF CAUSE OF DEATH.

I HEREBY CERTIFY that I attended deceased from.............................. 1...... to.............................. 1......, that I last saw h........ alive on.......................... 1......, that .... died on .... 1...... , about .... o'clock, ...M., and that to the best of my knowledge and belief the CAUSE OF DEATH was as hereunder written:

	Duration of each cause.
DISEASE CAUSING DEATH *..	....
Immediate cause of death	....
Contributory causes or complications, if any	....

Post-mortem................................... Place where DISEASE CAUSING DEATH was contracted, if other than place of death. ....

*In case of a *Violent Death*, state (1) mode of injury and whether accidental, suicidal or homicidal; (2) what was the nature of the injury and the immediate cause of death; (3) contributory causes or conditions, *e. g.*, septicæmia. Also whether operation was performed, etc.

In deaths from tuberculosis, cancer, etc., always specify what organ or part of the body was affected. In septicæmia, give cause, especially if puerperal.

Witness my hand this .... day of .... 1......

Signature of physician, health officer, or coroner ....M.D.

(Address)..

Upon the back of this certificate instructions to the undertaker are printed, together with an extract from the registration laws of the State. *Samuel W. Abbott.*

DEATH, MODES OF.—Life, whether systemic or molecular, depends upon the proper performance of the functions of circulation and respiration; so death, whether the result of disease, of violence, or of senile decay, is due ultimately to the cessation of these functions.

The causes which result in the permanent suspension of circulation and respiration operate directly upon their mechanism, or remotely through the nerve centres which regulate their action. So important indeed to the proper continuance of these functions is the maintenance of an uninterrupted action of the nerve centres of organic life that it is customary to adopt the classification of Bichat and to speak of death beginning at the heart, death beginning at the lungs, and death beginning at the head. For practical purposes this is sufficiently accurate, and it must be admitted that any attempt at a more definite classification is merely theoretical. The phenomena attending each of these modes of dissolution are at least sufficiently distinct to merit separate consideration.

CESSATION OF THE CIRCULATION may be sudden or gradual. The former is witnessed in deaths from syncope and shock; the latter, in those from asthenia. The chief force in the maintenance of the circulation is the normal difference in pressure of the blood in the arteries and veins. Any influence, therefore, that overcomes this difference will cause the circulation to stop. As the maintenance of this blood pressure is due chiefly to the action of the heart, the lesions that produce a fatal interruption of it are found for the most part in that organ. They may be found also in the vessels.

In the Heart.—When, from the occurrence of any organic or structural lesion, the heart is rendered no longer capable of propelling its contents into the arteries, the circulation is obliterated and death ensues. The movements of the heart may be suddenly and permanently arrested also by either direct central impulses, as by a gunshot injury, a blow upon the head, or such violent emotion as of fright, joy, or grief; by such direct or reflex impressions as those resulting from a blow upon the lower chest or epigastrium, or from the rupture of abscesses, cysts, or the gravid uterus; by the action of corrosive poisons on the mucous membrane of the stomach, or even by the ingestion of cold liquids in excess or when the body is in an overheated condition. Crile's recent experimental research leads him to the conclusion that collapse or death from violence applied upon the lower chest or abdomen is due mainly to the loss of rhythmic contraction from the mechanical irritation of such violence exerted on the heart muscle itself; that the solar plexus may be disregarded as a factor in it, and that the vagal terminal mechanism in and near the heart may contribute to it in a minor degree.

Syncope may be transient, however, as in fainting. There is then a momentary cessation of the heart's action, producing an anæmia of the cerebral centres, resulting in a brief period of unconsciousness and apparent death.

In a fatal syncope the individual suddenly turns pale, a cold sweat manifests itself, he becomes dizzy, the pupils dilate, vision becomes dim, the pulse slow, irregular, flickering, and in an instant life is gone. Or, the individual may suddenly become pale, make two or three convulsive gasps and drop dead. When the death is a little less sudden, as in fatal cases of hemorrhage, or when the perforation of an intestinal ulcer takes place, we may observe great restlessness, tossing to and fro, labored respirations, muttering delirium, and, as the scene closes, single or repeated convulsions.

In the Vessels.—When the cause of a sudden failure of the circulation is situated in the blood-vessels, it generally proves to be a rupture of their coats and the rapid reduction of blood pressure by the resulting hemorrhage. A condition closely allied to this sometimes results from an extreme dilatation of the blood-vessels of a single region. The most notable example of this is seen in the state of collapse that follows severe blows upon the abdomen, in which case the abdominal vessels are so distended as virtually to remove the greater part of the blood from the general circulation, and the heart soon ceases to beat from a lack of its normal stimulus. The individual is then said to die of shock. Shock differs from syncope in that the victim may for some time retain his consciousness; there may, however, be associated with shock a syncope due to the reflex inhibition of the heart, in which instance we have combined the symptoms of each. Shock, like syncope, may be transient, the vitality being gradually regained after a longer or shorter period of great depression.

A GRADUAL FAILURE OF THE CIRCULATION is the usual termination of a large number of diseases, particularly those of a chronic character. The heart ceases then on account of a failure of its own contractile power. This may result from degenerations of the muscular fibres, produced by continued high temperature, senile, fatty, or atrophic changes, the action of the micro-organisms of the infectious diseases, or of the poisons which they develop, or from such toxic sedatives as aconite, digitalis, and tobacco. In this category are classed also deaths from cholera, acute peritonitis, and such wasting affections as phthisis, diabetes, and cancer, as well as inanition and exposure to intense cold.

In this mode of death, the most prominent symptoms are great muscular debility and a feeble, rapid pulse. The intellect may remain clear to the last; but this, as well as the presence or absence of many other symptoms, must depend largely on the character of the disease upon which the death ensues.

CESSATION OF THE RESPIRATION.—Death from this cause is known as death by apnœa or asphyxia, and may be sudden or gradual.

Sudden failure of the respiration is due to a number of influences operating within or without the respiratory organs. The former class includes all obstructions and occlusions of these organs and all paralyses of their muscles as a result of injury or disease, local or central in character. Causes external to the respiratory organs include all obstructions by foreign bodies or by pressure upon any part of the respiratory passage, as in suffocation, strangulation by hanging or drowning, and the action of noxious gases.

The phenomena attending this mode of death are, violent efforts at respiration, followed, we are told, by sensations of pleasure and a brief period of remarkable clearness of intellect. The expiratory efforts become violent, unconsciousness and convulsions, or a few irregular twitchings of the muscles supervene, the face becomes swollen and cyanotic, the eyeballs protrude, then follows a period of relaxation, interrupted by occasional deep inspirations which finally become spasmodic gasps, and last of all, the heart stops.

A gradually fatal apnœa is a common result of disease. It is produced by any morbid process which gradually obliterates the lumen of the respiratory passages, *e.g.*, papillomata and other neoplasms of the larynx, œdema of its mucous membrane, false membranes of the trachea and bronchi, œdema of the lungs, and the pneumonic exudation. Failure of the respiration is occasionally the prominent symptom in death from phthisis (catarrhal pneumonia), and it may result from the pressure of large abdominal tumors or ascites.

Individuals dying in this manner exhibit much the same series of symptoms as those whose death is more sudden, but the struggle is less pronounced.

DEATH FROM CENTRAL PARALYSIS.—Paralysis of the vital nerve centres, or "death beginning at the head," operates by causing a failure of the circulation or respiration. Diseases, whether primary or secondary, and injuries located in the cerebrum or the cerebellum, may result fatally through extension of the inflammation to the pons or medulla or through the production of abnormal pressure upon them. Deaths from electric shock, lightning stroke, and electrocution belong to this class. Such poisons as the toxins, ptomaïns, and leucomaïns, and certain drugs, especially the narcotics, impress, as a rule, both cerebral and spinal centres and, when in sufficient quantity, ultimately overcome respiration and circulation.

The most prominent symptom indicative of approaching death from this cause is unconsciousness, or coma, when death is not instantaneous. All reflex movements soon cease; the respiration becomes stertorous, gradually more slow and labored, and at last stops, tranquilly, or after convulsive manifestations.

Finally, it should be remembered that the instances in which a death can be clearly traced to the failure of a single group of organs is the exception and not the rule. On the contrary, it will generally be observed that with the ebbing of life, the failure of one system follows so closely upon that of another as to render it extremely difficult to determine which of the vital functions is the last to cease. Death beginning at the lungs may be delayed by the employment of artificial respiration, death beginning at the head may for a time yield to the influence of appropriate remedies; but when the heart has been stilled no human power can restore it to action.

James M. French.

DEATH, PHYSIOLOGICAL THEORIES OF.—Living things, in the forms most familiar to us, at least, all grow old and die. We infer that this fate is universal with something of the same certainty with which we prophesy that a stone thrown into the air at any spot whatsoever will fall back to the earth's surface. On the other hand, it is equally a commonplace of observation that the death of the individual does not mean the death of the race, and, inasmuch as every living thing is directly sprung from a preceding form—*omne vivum e vivo*—we may assume that the continuity of life has never been interrupted, and never will be. If the environment remains as favorable in the future as it has been in the past, living things will continue in unbroken succession for all time. From this standpoint we may speak justly of living matter as possessing immortality, or, at least, potential immortality, since it has unlimited powers of propagation. It is one of the final aims of biological speculation to reconcile these two apparently paradoxical properties of living matter; to furnish a satisfactory hypothesis that shall explain the occurrence of old age and death in the individual, and at the same time account for the possibility of unending existence for the race that is implied in the fact of reproduction.

In speculations of this character we must, moreover, keep clearly in mind that forms of living matter are not stable, in the same sense that forms of dead matter are. A given animal exists for a period of five years; but we are all perfectly well aware that no portion of the living substance of this animal has necessarily remained actually the same throughout this time; *i.e.*, the atoms of C, H, O, N, S, P, that constituted the living matter in the beginning, may have been replaced very early by others brought in with the food. What has remained unchanged through the individual's life has been, on the physiological side, a form of activity, and, on the morphological and chemical side, a material substratum of a practically definite composition. However familiar this fact may be, it is, after all, the great distinctive feature of life—or rather, of living matter. We express in the single word assimilation, or nutrition, that property which most distinctly separates living matter from dead. As long as any particle of matter is in the living form, just so long has it the creative power of converting dead food into living substance like itself. Throughout its period of existence there is a steady stream of dead matter coming to it to be rearranged into the living form, and an equally continuous outflow of dead material that had once been in the living form. Nothing can make this conception clearer than Huxley's simile of the whirlpool at Niagara—which fits so well as an illustration of the ever-changing particles that make up the unchanging form of life. From this point of view we may say that living matter is never actually the same, yet it must be evident that, in respect of any given mass of that body which we call protoplasm, it can reproduce itself only in its offspring by transmitting a portion of its actual substance. The formation of a new organism from this transmitted germ is therefore, from a chemical standpoint, no more a creation of a new being or of new living material than is the continued existence of the parent form throughout its period of natural life.

As far as the mere external phenomena of senility are concerned they may be observed and recorded. In the human being this has been done with more or less care. The coming on of the signs of old age in the different tissues, the rate of its normal development, and the conditions that hasten or retard its development, are known to a certain extent, though they have not been investigated with the carefulness of detail that scientific exactness requires. We cannot expect any solid advance in our knowledge of the development of old age until the statistics, which may be determined by experiment and observation, have been recorded. The superficial signs of old age are spoken of usually in the text-books of physiology. In the old, the bones become more brittle because of a continually increasing excess of deposits of inorganic salts; the cartilages become more rigid and calcareous for the same reason; the elasticity of the lens of the eye decreases, bringing on imperfect accommodation; the muscles atrophy and lose their physiological mobility, as shown by the lessened vigor of their contractions and their diminished elasticity; the nuclei of the nerve cells decrease in size and show other signs of deterioration; the hairs lose their pigment, etc. It is important to notice that these signs of deterioration in the machinery of life do not make their appearance first during or after the period of maturity, but begin to develop from the time of birth, or possibly before. At ten years of age the near point of distinct vision is 7 cm. from the eye, at twenty it has lengthened to 10 cm., at forty years of age it is 22 cm., at sixty years it is 100 cm., and so on. The long-sightedness of old age begins to develop in early childhood, and results physiologically from a continual diminution in the elasticity of the lens. We obtain similar facts if we measure the rate of growth of the body throughout life. According to the somewhat unreliable statistics of Quetelet, the average male child weighs at birth 6½ pounds. At the end of the first year it will weigh 18½ pounds, a gain of 12 pounds. At the end of the second year it will weigh 23 pounds, a gain of only 4½ pounds. And so on to full maturity the rate of increase each year falls rapidly. If we measure the rate of growth by the increase in height instead of by the increase in weight, we find that in the first year the gain is 148 mm., in the second year it has fallen to 93 mm., in the third to 72 mm., from the twentieth to the twenty-fifth year it averages 12 mm., and from the twenty-fifth to the thirtieth year only 0.8 mm., while in extreme old age it becomes a negative quantity.

In a valuable paper Minot has given the results of a laborious research upon the growth of guinea-pigs, which show much more clearly and accurately the same general fact of a decrease in the rate of growth beginning shortly after birth. Minot bases his figures upon observations taken daily. He defines the term "rate of growth" with an exactness not hitherto employed, in that he calls attention to the fact that usually, in considering the rate of increase, the actual increment at different periods is given instead of the proportionate increment. In other words, if an animal in successive periods gains in absolute quantities only the same amount in weight or height, its rate of growth is in reality decreasing, since proportionately to the weight of the whole animal the increase has been less and less. Making use of his short periods of twenty-four hours, and expressing the rate of growth as the fraction of weight added during that period, he finds that, after the animal recovers from a short post-natal retardation of growth, the rate of growth diminishes during life, at first rapidly, and afterward more slowly. The curve, however, is not by any means a regular one, the steady decline is marked by irregular ascents, the most notable and regular of which is the acceleration at the time of puberty. It follows from these facts that what we may call the creative power of growth, or better, the creative power of assimilation, which measures the capacity of living matter to form matter like itself, decreases steadily from birth. Like a stone projected upward, the initial velocity begins to fall from the outstart. As the height to which the stone travels may be taken as a measure of the force with which it was thrown, so the length of life in any individual may be taken as a measure of the power or capacity of assimilation with which the germ of that individual started its career. When the power of assimilation is insufficient to replace the wastes of nutrition then death for that tissue is at hand. Whatever may be the internal causes which lead to this diminution, and thus serve to bring on old age, we are safe in saying that they begin to make themselves felt in the very first years of post-natal life. The curve of vitality—to use a much-abused but convenient word—does not rise from birth, reach its maximum in the vigor of maturity, and fall in old age, but begins to fall steadily, though not uniformly, from the beginning of life. This statement applies to the mass of living matter in the body, but the same general conception holds good for the organization of this mass into physiological mechanisms, such as the brain, the circulation, etc. These mechanisms are incomplete at birth and become more perfect toward adult life, the maximum efficiency being reached at different periods, that for the neuro-muscular apparatus, for example, being attained at an earlier age than that for the brain. Exact data are lacking, but we may suppose that the percentage of increase toward this maximum shows also in each case a declining curve with advancing years.

To mankind as individual organisms old age and death are inevitable, but it is interesting to inquire what may be considered the longest possible life under the most favorable conditions this world is likely to afford. We can answer this only by searching the records. If we put aside the oldest accounts on the ground of uncertainty as to the unit of time, and make our estimates on the basis of comparatively modern statistics, we may put the maximum age as lying somewhere between one hundred and twenty and one hundred and eighty years. Perhaps the most celebrated case of longevity is that of Thomas Parr, an account of whose life, together with the results of a post-mortem examination made by Harvey, may be found in the third volume of the "Philosophical Transactions," p. 886. The account relates "that he was a poor countryman of Shropshire, whence he was brought up by the Right Honorable Thomas, Earl of Arundel and Surrey, and that he died after he had outlived nine princes, in the tenth year of the tenth of them, at the age of one hundred and fifty-two years and nine months." Other interesting extracts from the letter of Harvey are as follows: "The cartilages of the sternum were not more bony than the others, but flexile and soft." The cause of his death was imputed chiefly to the change of food and air; "forasmuch as coming out of a clear, thin, and free air, he came into the thick air of London, and after a constant, plain, and homely country diet, he was taken into a splendid family where he fed high and drunk plentifully of the best wines." "He was able, even to the hundred and thirtieth year of his age, to do any husbandman's work, even threshing of corn." It is also stated that he married a widow when one hundred and twenty years of age, and from her own statement had frequent sexual intercourse with her. In an essay by Pflüger on macrobiotics, he refers to other recorded cases of unusual longevity. H. Jenkins, a native of Yorkshire, died, in 1670, at the age of one hundred and sixty nine. It is related that on one occasion, when brought before a justice to testify with reference to an event which had occurred one hundred and forty years before, he appeared accompanied by his two sons, aged one hundred and two and one hundred years, respectively. A more remarkable case still is that of Kentigern, or Saint Mungo, founder of the Cathedral of Glasgow, who reached an age of one hundred and eighty-five, if we may trust the accounts of his life on record. Among the exceptional cases recorded some are stated to have been unusually temperate in their habits of life, while others paid no regard to such precautions. In this last category Pflüger mentions one Brawn, who reached an age of one hundred and twenty, although his tombstone records the fact that he was a confirmed drunkard. Outside of such evidence as this, it is evident that exceptional longevity cannot be referred solely to careful observance of hygienic conditions. We must explain it, in general terms, as due to an unusual power of assimilation in the living substance composing the tissues, and that this tendency to long life is inherited may be accepted as demonstrated by the statistics of life insurance. At the present day we have numerous cases of persons passing the hundred-year mark by a few years, so that this age cannot be regarded as very unusual. Sir C. Brown, for example, in his interesting paper on old age, states that in 1889 the deaths of seventy-six reputed centenarians were reported in England and Wales.

However, leaving aside the reproductive cells, death sooner or later comes to the rest of the cells of the body, no matter how favorable the environments of life may be. It is not altogether hopeless to inquire into the causes which bring this about, though naturally any such investigation is largely made up of speculation of a very general character. We may define death as a cessation of life. In order, therefore, to arrive at even a general conception of its cause one must first define as clearly as possible what is meant by life. Spencer's definition is perhaps the one most familiar to educated persons. According to him life is the continual adjustment of internal to external relations. When properly analyzed the definition includes a great deal, and it is difficult to criticise it justly. But the physiologist will certainly object to it, because it attempts to present, in the most general terms, only the *ensemble* of properties manifested by living matter without pretending to trace these properties in any causative way to the physical substance that manifests them. It is as though one defined light by enumerating its chemical and physiological effects instead of referring it to vibrations of the ether. For the physiologist an adequate definition of life must be one that connects its phenomena with the structure of living matter. As the chemist may deduce the chief properties of a salt from a knowledge of the structure of its molecule, so the physiologist believes that a scientific explanation of life—that is, of the phenomena of assimilation and reproduction—can be obtained only by discovering the essential structure of living matter. To this end all biological work tends. The adjustment of internal to external relations, and the interaction of the different organs that brings about this adjustment, should be deducible from the chemical structure of living matter in somewhat the same way that the adjustments or reactions of benzene to different external conditions may be foretold from a knowledge of its molecular structure. That this kind of explanation of life is not inconceivably remote is demonstrated by the fact that several chemical theories have been seriously proposed and applied in some detail. Pflüger, for example, suggests that the essential difference between dead and living proteid lies in the grouping of the nitrogen in the molecule. In dead proteid it may exist in the form of an ammonia compound, while in proteid that is living it occurs in part, at least, in the cyanogen grouping. As something approaching scientific evidence for this view he asserts that the oxidation products of dead albuminous bodies—that is, as far as the nitrogen is concerned—are always ammonia compounds, amines, or amido-acids, while the end products of the oxidations of living substances may be classed among the cyanogen bodies. Moreover, the cyanogen compounds are characterized by their instability, and this is likewise one of the most prominent phenomena exhibited by living substances; it is doubtless the chemical cause of what is known as the irritability of living things. Cyanogen compounds also exhibit, in a striking way, a tendency to polymerize, and Pflüger suggests that this property of polymerization may be the essence of what we speak of in general as assimilation or nutrition, by which the living molecule takes into itself the molecule of dead proteid. Indeed, says Pflüger, we may look upon the molecule of cyanic acid as showing properties intermediate between those of living and dead matter, as a half-living substance. In a similar way Loew and Bokorney attempt to explain the peculiar properties of living matter on the supposition that its molecule contains an aldehyde group. They find that living protoplasm, in certain plant cells at least, has the property of reducing silver nitrate from alkaline solutions, while dead proteid has no such action. They infer that this reducing power is caused by the presence of an aldehyde group, and they give a schema showing that formic aldehyde, by union with ammonia, may produce aspartic aldehyde, and this, by condensation and reduction, with the addition of S, might give a compound of the molecular formula of proteid, which as long as it retained the aldehyde grouping would be living proteid, and would form the basis of living protoplasm. Latham attempts to combine the theories of Loew and Pflüger by supposing that living proteid is composed of a chain of cyan alcohols, united to a benzene nucleus, thus explaining the irritability or instability of living proteid, as well as its reducing action. However inadequate and premature such hypotheses may seem at present, they at least serve to demonstrate the fact that the physiologists and chemists are looking forward to a definition of life based upon a knowledge of the chemical structure of the substance through which it is made manifest.

Proceeding from his conception of what constitutes life, Spencer defines natural death as a want of correspondence between the internal and external relations. Perfect correspondence would mean eternal existence.

If the organism could adapt itself to every change in its environment, old age and death would be impossible. It is difficult to understand the full significance of Spencer's language. Taken literally it seems to assert nothing more than that death is a cessation of life. It adds nothing at all to our knowledge of the causes leading to this cessation, nor does it indicate any fruitful line of investigation. If, however, Spencer means that the fatal want of correspondence may come from without; that is, from changes in environment to which no adequate adaptation can be made by the organism, and in many passages this seems to be implied, then his view is opposed to that accepted by most physiologists. They, the physiologists, believe in general that although the environment were perfect and unchangeable, yet by virtue of inherent changes in the organism itself the assimilative powers would inevitably grow weaker and finally cease with death, or as the same idea is expressed by Brown: "The causes of death are not to be found in the summation of many external injuries, but are already established within the organism itself, and death is simply the natural end of development." In want of a more exact knowledge of the structure of the living molecule and the changes in structure that come on in old age, the physiologist expresses his ideas of the general nature of these changes by similes and metaphors more or less apt. We may compare living matter to a clock, the mainspring of which is so constructed that in consequence of slowly developing molecular changes it suffers a gradual loss of elasticity. In such a mechanism there will come a time when "winding the clock up" will no longer make it run, since energy can no longer be stored in the spring. We may imagine this loss of elasticity to develop gradually, giving stages that may be roughly compared to the periods of life. To carry out the simile, it is the food we eat and the oxygen we breathe that take the place of the winding force. In consequence of a slowly developing molecular change in the organism, this energy is less efficiently utilized as the individual grows older. The clock runs more feebly and needs relatively more frequent winding, until at last the elasticity is gone, the power of assimilation is insufficient, and we have what we call natural death. In complex organisms like ourselves this failure of assimilation may come first to some one organ, such as the heart or the nervous system, and through its collapse the organism as a whole cease to exist. In the nature of the case natural death cannot come to every organ of the body at the same time, so that the death of a portion, perhaps from the standpoint of weight, the larger portion of the body, must always be accidental, as, for example, from a shutting off of the blood supply due to natural death of the heart. But this consideration does not affect the general conception of the liability of all the organs to a similar fate. Rightly or wrongly, it is, or has been, a wellnigh universal belief that every organism and every bit of living matter in an organism has only a limited duration of life, no matter how favorable the external conditions may be.

In striking opposition to this view, Weissmann, in a recent series of essays upon the duration of life, has attempted to demonstrate the essential immortality of living matter, or, in other words, to show that death is not an inherent necessity of life, but an acquisition or adaptation on the part of living things. These essays have aroused a widespread interest and discussion among biologists, and are probably the most important speculations of recent times upon the origin and meaning of death. Weissmann carries the problem back to the lowest forms of life, the unicellular organisms or protozoa. Whatever in this regard is true of them must be looked upon as being or as having been true for living things in general, since modern biological doctrines trace the evolution of life from these forms, and modern morphology has demonstrated that all complex forms of life are in fact mere colonies or collections of unicellular organisms. If we study one of the protozoa, the amœba, for instance, which has always been taken as the archetype of life, we find that it is a complete cell; that it feeds, and assimilates, and excretes; that it increases in size, and finally reproduces by simple fission, forming two new individuals, or daughter cells. In this last process we have the disappearance of one old individual and the formation of two new ones, nevertheless there is no death. To speak of the disappearance of the parent cell as an example of death, as some have done, is a mere figurative use of language. There is no death in such a change, because as Weissmann puts it, there is no corpse. If we consider the two daughter cells produced by the fission, we find not only that they are similar morphologically, but that each of them has possibilities of growth and reproduction equal to those shown by the parent form—there is apparently no reason why such a process should not go on indefinitely. Amœbæ, as we find them under the microscope, show no signs of old age; the daughter cells are not less capable of reproduction than is the parent cell. It is permissible to suppose that if a single amœba were given a favorable environment it would in time produce an infinite number of descendants, each of them possessing in turn the same unlimited possibilities of multiplication. This is precisely the hypothesis that Weissmann makes when he says that living matter is potentially immortal. It is an alternative hypothesis to the one usually adopted, and Weissmann's contribution to the subject comes not so much from his adoption of this view as from the application he makes of it in considering the higher forms of life in which death is an indisputable reality. Weissmann's theory of the origin of death among the metazoa is developed directly from his hypothesis that living matter was originally incapable of natural death. His direct statement that the simplest unicellular forms of life to-day probably retain this primitive constitution of protoplasm has not, however, passed unchallenged. Maupas has made an experimental test of the statement in some very interesting observations. He set himself to observe, throughout an extended period, certain unicellular animals when placed under the most favorable conditions for growth and multiplication. The infusoria were chosen for experiment. After making careful observations upon the best conditions of temperature and food, an individual was selected, placed upon a microscopic slide in a suitable moist chamber, and kept under the most favorable conditions possible for propagation. A faithful record was kept each day of the increase in number, through multiplication by division, of the specimen chosen for study. After the increase had reached some hundreds of individuals, one of them was again isolated and allowed to multiply, and so on until unmistakable signs of what he calls a senile degeneration became apparent in the offspring. His experiments lasted for a variable time. In no case were the observations carried over less than fourteen days, and in the case of stylonichia pustulata, upon which the most careful experiments were made, the successive progeny were cultivated for nearly five months.

The rate of growth in some of the species was incredibly fast. Maupas estimates that in six and one-half days a single stylonichia, at a temperature of 25° to 26° C., might produce by repeated fissions a body of protoplasm weighing 1 kgm., and in thirty days a mass of protoplasm a million times larger than the sun. He was able to observe that after a certain number of generations the progeny began to show signs of a physiological decline. The new animals formed were smaller than normal, seemed weaker, were not so well provided with cilia, and the nuclei contained within them gave microscopical evidence of pathological changes. Maupas looks upon this result as proof of a genuine senility which would have resulted—had the process of isolation been continued sufficiently long—in the natural death of all the descendants, despite the most favorable conditions for living.

After a colony began to show signs of old age he found that if one of the animals was taken out and mixed with another lot having a different ancestry, conjugation took place. The weakened infusorian united sexually with one of the more youthful forms, and rejuvenescence was thereby secured. The descendants of this pair multiplied again with the original vigor and gave rise to normal healthy offspring. Weissmann takes exception to these experiments. The infusoria are the most highly developed of the unicellular animals, showing a marked degee of specialization of structure. Furthermore, they are known to conjugate at certain periods in their life history. A pair will come together and exchange a portion of their nuclear material, after which each begins to multiply by simple fission with renewed vigor for a certain undetermined period. It may be that in so highly a differentiated form the primitive reproductive power of protoplasm has been specialized in a particular structure of the cell, as in the higher animals it has been reserved only to the germ cells; so that in this regard the infusoria might be classed with the metazoa rather than with the protozoa. Moreover, it may be doubted whether Maupas really kept his captive infusoria under perfectly normal conditions. Outside the mere question of food the possibility of not retaining a perfectly normal balance in the inorganic constituents of the medium suggests itself at once. In some more recent experiments of the same character reported by Joukowsky results more favorable to Weissmann's views were obtained. Joukowsky used several species of infusoria. His method was to isolate an individual in a moist chamber and feed it carefully. After several days this individual by fission had given rise to a colony of perhaps sixty to one hundred offspring. One of these was then isolated, treated in the same way, and this process was kept up in some cases for many months. His most striking results were obtained with pleurotrichia lanceolata, which he observed during eight months and through four hundred and fifty-eight generations. During this time no conjugations were seen, and no signs of degeneration or senescence, such as Maupas described, were noticed. Granting, however, that no exception can be taken to the experiments as made by Maupas, and that his results are correct, Weissmann contends that in the more primitive forms, in which reproduction is always by simple fission and anything approximating sexual conjugation is unknown, his fundamental hypothesis must still be true—death can occur only by accident, and not by natural decay. In the amœbæ, bacteria, and similar forms of life no conjugation has been discovered. While the conditions of life are favorable, growth and multiplication go steadily on. When the conditions of life are unfavorable—*e.g.*, when moisture is withdrawn—forms like the amœba may become encysted and cease to show the properties of living matter until more favorable conditions prevail. Götte has seized upon this process of encystment as the equivalent of death, but we shall speak of the theory of this author after Weissmann's theory has been stated.

Let us assume that Weissmann is right in his fundamental hypothesis, and that the first forms of life were potentially immortal, as the simplest forms of life are today. What, then, has become of that immortality in organisms like ourselves? What was the origin of death? Weissmann makes the supposition that in the higher animals we have two kinds of living matter, one composing the mass of the body, which unquestionably is subject to a natural death, and one composing the reproductive cells, which is evidently possessed of potential immortality, since if fertilized and kept under proper conditions it will give rise to an infinite number of descendants. The former, the mortal, he speaks of as somatoplasm, the latter, the immortal, as germ plasm. Furthermore, he supposes that the germ plasm, constituting the reproductive cells in any individual, is directly derived from the fertilized ovum from which that individual developed. The fertilized ovum is a single cell; by cell division it multiples a billion-fold and more to make the body. Of this infinite number of cells those which make up the muscles, skin, etc., although directly derived from the ovum, have become specialized physiologically as well as morphologically to fit them for the performance of their special functions, and at the same time they have lost the potential power of immortality which characterized the germ plasm of the ovum. But among this infinite number of cells there are always certain ones that do not undergo specialization; they remain like the ovum from which they were formed; they retain a portion of the germ plasm with its powers of immortality, and these cells become the ova and spermatozoa from which new organisms may be developed in turn. If we carry back this conception through the line of ancestral forms from which man has been developed, it involves the idea that the germ plasm has been actually continuous throughout the history of living things, and that it represents the immortal protoplasm of the unicellular forms from which the metazoa were evolved. This is the doctrine that goes by the name of the "continuity of the germ plasm," and in the form in which it is presented makes one of the most original contributions given to biology within recent years. The question as we have it before us now may be stated in this way: The unicellular forms are potentially immortal; the many-celled animals contain an immortal germ plasm and a mortal somatoplasm, and yet the many-celled animals have been directly derived from the unicellular forms. In the first many-celled animals produced, the different cells must have had similar properties; they must all have been equivalent to reproductive cells. But subsequently, after specialization of structure and physiological division of labor had become established, it happened that the vast majority of the cells of the body, all those in fact that had undergone differentiation in structure and function, lost the power of perfect nutrition, and became subject to old age and death. Upon what biological grounds can we explain this variation? Weissmann refers it to the operation of the law of natural selection, and states his theory briefly in saying that death is an adaptation, acquired because of its utility to the race on the one hand, and, on the other hand, because, after the beginning of a differentiation in function among the cells, the possession of immortality by all the cells was no longer of any value to the race, and therefore was not brought under the preserving influence of natural selection.

With reference to the first of these reasons, the utility of death to the race, it must be borne in mind that the operation of the law of natural selection is directed entirely toward the perpetuation of the species. Anything that endangers this perpetuity will be discarded, and the duration of life of the individual is a point worth fighting for, or against, only in so far as it influences the struggle for existence of the species. If natural death had not appeared, and creatures could have been destroyed only by fatally adverse changes in their environment, then we may imagine that every species would have been burdened in its fight for existence by individuals whose physical value had been impaired by previous minor accidents, such as loss of limbs, etc. There would have been, from the pitiless standpoint of natural selection, many useless mouths to feed. Weissmann was inclined in his first essays to lay great stress upon this point, but in later years he emphasized chiefly the second of the reasons given above, namely, that immortality was lost to the non-reproductive cells because, being of no direct value in the perpetuation of the species, it was not acted upon and preserved by natural selection. The tendency of structures to retrograde and disappear when their value to the species becomes *nil*, even though they may not be actively injurious or burdensome, because natural selection no longer acts to preserve them, is something of a new idea in biology. Weissmann attaches great importance to it, and has coined for it the term panmixia. A simple example of its action is seen in the absence of eyes in the cave-inhabiting animals. Many of the crustacea living in the dark caves have lost their eyes—by panmixia, Weissmann would say; that is, in their peculiar environment their eyes are no longer of use, and they have therefore degenerated and disappeared, in the course of generations, by the lack of the direct preservative influence of natural selection. So Weissmann thinks that the original immortality of living matter became lost to the non-reproductive cells in the many-celled animals because, being of no value to the species, indeed, on the contrary, threatening the species with an unnecessary burden, natural selection let it alone. To the writer's mind this kind of argument, indeed, the whole idea of panmixia, seems to be very incomplete, it lacks all suggestion of a specific cause. In physiology we are familiar with many examples of retrogression of structure following upon disuse. A muscle or gland thrown out of function by severance of its motor nerve, or a nerve cell cut off from its normal connections, atrophies from disuse. But the explanation given is specific to the extent that it refers the atrophy to an altered metabolism. Functional activity in specialized tissues seems to be necessary for their normal metabolism, and lack of activity, as in the paralyzed muscle, is followed by a perverted metabolism that results in the destruction of the tissue. In the same way the loss of perfect nutrition in the somatoplasm might readily be referred, as in Weissmann's first explanation, to an altered metabolism that, arising spontaneously, was subsequently preserved by natural selection, because it proved advantageous to the species.

Many eminent biologists have found a logical difficulty in understanding how from cells originally immortal cells that were mortal could have been derived by differentiation of any kind. They hold that natural selection can operate only upon a structure that exists, it cannot create a thing outright. If living matter was all originally immortal, how could natural selection, by negative or positive action, produce mortality, if in some degree this latter property was not already inherent in living matter. As one of the objectors (St. George Mivart) puts it, the difficulty is to understand the first step, the beginning of something from nothing. Objections of this kind are of course fallacious; it is curious that they should have been seriously made by eminent men. The words mortality and immortality do not stand for definite things; they are not substances or entities, or whatever term of this kind one may choose to use. On the contrary, they are in this case merely convenient phrases to express the kind of nutrition going on in living things, whether it is self-perpetuating or self-limiting. They are properties that are connected with the physical or chemical structure of living matter, and this latter is a thing that does exist and may be acted upon and modified by natural selection in many ways. Weissmann's conception of an early differentiation in the developing embryo of a somatoplasm and a germ plasm has not seemed to meet with favor in the eyes of many competent biologists. These have claimed that in the early segmentation of the ovum the separate cells that are formed are essentially equivalent; that a complete embryo may be formed from a half or quarter of the egg, and that the nuclei first arising may be changed about experimentally "like a heap of billiard balls" without altering the course of development. In thus denying that the orderly course of development is controlled entirely from within, by a system of differentiating divisions of the ovum, these authors are led to lay more stress upon what may be called external forces. As Hertwig expresses it: "I regard the divergent differentiation of cells as a reaction of the organic material to unlike impelling forces." This point of view would seem to be incompatible with the conception of a continuity of the germ plasm, and it has been said with much force that the truth of this latter hypothesis has not been actually demonstrated. However, those who oppose Weissmann's views become involved themselves in numerous undemonstrated assumptions, and seem often to miss the physiological truism that continuity of living matter does not imply an unchanging organization, but rather a perpetuity of nutrition, a perfect metabolism whereby waste is completely repaired, senescence is made impossible, and death is conceivable only as the result of accidental causes.

In accepting or refusing Weissmann's theory of the origin of death, everything seems to depend upon the validity of his fundamental hypothesis with regard to the absence of natural death among the primitive forms of life. If we admit that there are simple organisms, such as the bacteria or the amœbæ, that do not propagate by conjugation or by any method of multiplication other than simple fission, it would seem logically impossible for such a species to be perpetuated unless its protoplasm is exempt from senility. If we do not accept this solution, then we must suppose either that there is some kind of sexual rejuvenation that has not yet been discovered in these particular forms, or that there is some process of molecular rejuvenation occurring at periods in the life history of such forms that brings the living substance back to its primitive constitution and nutritive vigor. Götte has clearly recognized this necessity, and has proposed a theory that is logically acceptable. According to Götte, death is a necessity immanent in life. As regards the unicellular forms of life, he avoids the difficulty that has just been described by assuming that the process of encystment is the death of the old individual and the beginning of a new one. Encystment, of course, is known to occur among the unicellular forms. During the process the visible evidences of life, such as movement, come to an end, to be renewed again after a certain period, or under more favorable conditions. Götte believes that during the encystment a change of molecular structure takes place. There is first a dissociation or dissolution, which is an actual death, inasmuch as the properties of living matter are lost. This, however, is succeeded by a stage of reconstruction with the formation of new protoplasm possessed of the primitive powers of assimilation, and capable of developing and multiplying for a certain period. This is obviously an hypothesis that it is practically impossible to test by chemical investigations. To the physiologist it will probably not be acceptable on theoretical grounds because of the difficulty of conceiving how matter once in the dead form can again pass into the living form, as the result of spontaneous molecular activities, and without the aid of an exciting or liberating force. Dead matter, as we know it, is converted into the living form only by the process of assimilation on the part of matter already living, whereas the hypothesis of Götte calls upon us to believe that the transition may take place by virtue of the intermolecular movements in the dead matter itself. Encystment, then, according to the theory of Götte, represents at the same time the primitive form of natural death and the primitive method of reproduction. As the metazoa have been derived from the unicellular forms, he further assumes that among the former both natural death and reproduction have been acquired by direct inheritance. As in the protozoa reproduction and death stand in a causal relationship, so in the simpler forms of metazoa, *e.g.*, in the orthonectidæ, this connection is still maintained, inasmuch as the liberation of the ova results in the death of the individual. Among the higher forms the relationship between reproduction and death is not so evident, though the theory demands always a causal connection between the two processes.

It will be evident from this brief statement of Götte's views that he differs from Weissmann, not only in his belief of the necessity and universality of death, but also in respect of the discontinuity of life. Among the protozoa, that propagate by encystment, his theory denies that the new individual is directly sprung from the living substance of the parent cell. On the other hand, the general belief has been that in some way the continuity of life is maintained. Darwin's theory of pangenesis, which was formulated to explain the phenomena of heredity, implies a continuity of living matter between parent and child. It will be remembered that in this theory the ova and spermatozoa are supposed to contain minute germs, gemmules, thrown off from the different cells of the body and collected in the germ cells. Under the proper physiological stimulation, the gemmules develop into organs like those from which they were derived. The gemmules must be regarded as living matter; hence the theory implies a direct carrying over of living substance from parent to child, a continuity of living matter at least. In contrast with this the theory of Weissmann supposes a direct continuity of germ plasm, the essential part of the germ cells of the child being an actual portion of the germ protoplasm of the reproductive cells of the parents. The immortality of the germ plasm and the direct continuity of the germ plasm are, then, the fundamental parts of Weissmann's theory, and his hypothesis of the origin of death as regards the somatoplasm follows naturally if we accept these premises. It will be observed, however, that Darwin's pangenesis theory may also be regarded as implying the essential immortality of the material composing the germ cells, although neither Darwin himself nor those who have made use of his theory have ever made a specific statement of this kind.

In the older treatises upon the nature of death a distinction was often made between molecular death and somatic death. The former term was meant to include those changes of disassimilation or katabolism, to use a more modern word, which are supposed to be in play in every bit of living matter, and to lead to the formation of dead waste material, such as urea, carbon dioxide, and water. Somatic death was used, as it is at the present time, to describe the final cessation of all vital activities in the body at large. It was supposed that we had here the production of dead from living matter by two entirely different methods. The term molecular death is obviously an unhappy one, and has fallen into disuse, although it is possible that it is an accurate statement of what takes place. The essential nature of the physiological oxidations which lead to the formation of the products of disassimilation is at present a subject of discussion, and will probably remain so for a long time. Treating the subject in the most general way, it seems evident that in disassimilation one of two things may take place. If, for the sake of simplicity, we confine our attention to a single cell, then it is possible, on the one hand, that the formation of the wastes of nutrition is brought about by the actual death and disintegration of portions of the cytoplasm, their places being supplied by new living material formed in other parts of the cytoplasm or in the nucleoplasm. Or, on the other hand, it is equally possible that in normal disassimilation no single living molecule undergoes total destruction. The process of dissociation may be such that only a portion of the molecule is split off, and lost from the cell as dead material, while the remainder of the molecule reconstructs itself from the food material of the cell juices into the originally complex molecule of living matter. This, in fact, is the hypothesis of physiological oxidation which has been proposed by Pflüger with special reference to the metabolisms of muscle during functional activity. His theoretical views have much to recommend them, and some account of them is usually given in the text-books of physiology.

W. H. Howell.

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DEATH, SIGNS OF.

See *Cadaver, Legal Status of.*

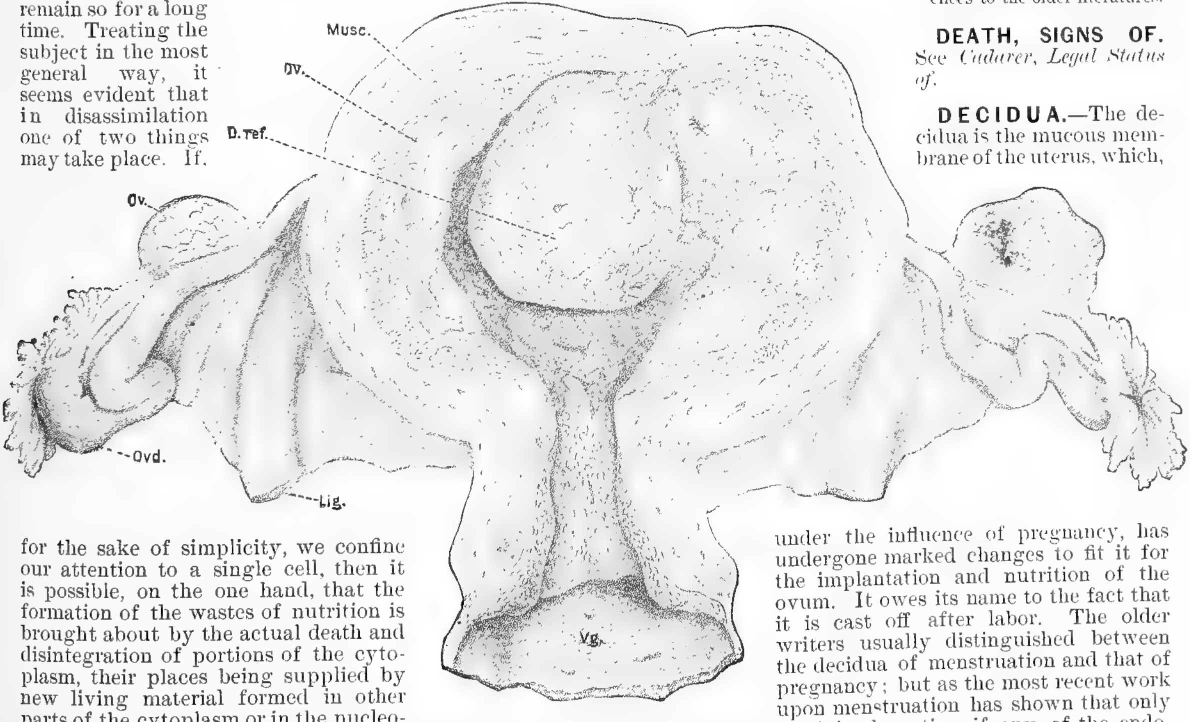

FIG. 1577.—Uterus about Forty Days Advanced in Pregnancy. (After Coste.) *Musc*, Muscularis; *Dv*, decidua vera; *D. ref*, decidua reflexa; *Ov*, ovary; *Ovd*, Fallopian tube; *Lig*, round ligament; *Vg*, vagina. The uterus has been opened by cutting through the anterior wall, and reflecting the sides.

DECIDUA.

DECIDUA.—The decidua is the mucous membrane of the uterus, which, under the influence of pregnancy, has undergone marked changes to fit it for the implantation and nutrition of the ovum. It owes its name to the fact that it is cast off after labor. The older writers usually distinguished between the decidua of menstruation and that of pregnancy; but as the most recent work upon menstruation has shown that only a minimal portion, if any, of the endometrium is cast off at that time, the employment of the former term does not appear to be justified.

We are not able to state exactly when the decidual formation commences, but it must be almost immediately after the fertilization of the ovum, as fairly well-marked deciduæ were present in uteri described by Peters and Leopold, which were respectively three and seven days pregnant. Under the influence of pregnancy, whether occurring in the uterus or tubes, the smooth, velvety endometrium becomes markedly thicker and its surface marked by numerous irregular furrows which give it a mammillated appearance, and under the magnifying glass numerous small openings can be distinguished, which represent the mouths of the uterine glands. The decidual formation is limited to the body of the uterus and does not extend below the internal os; though in rare instances, as stated by Franqué and von Weiss, isolated decidual cells may be found beneath the epithelium of the cervical canal.

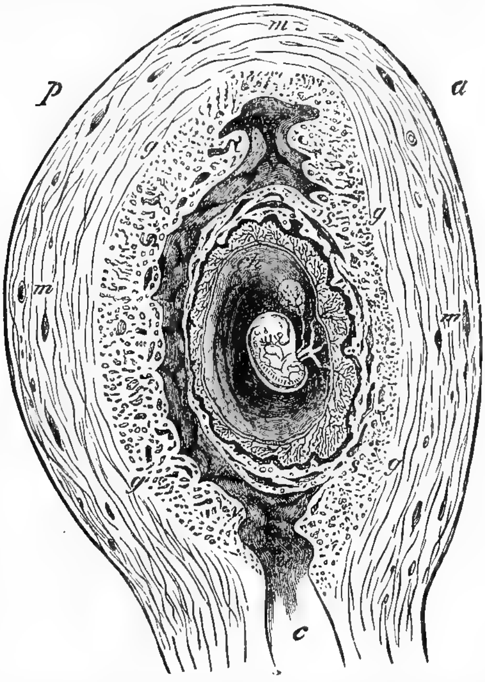

FIG. 1578.—Semi-Diagrammatic Outline of an Antero-Posterior Section of the Gravid Uterus and Ovum of Five Weeks. (After Allen Thomson.) *a*, Anterior surface; *p*, posterior surface; *m*, muscularis; *g*, inner margin of metamorphosed mucosa; *s* to *s*, area of *decidua serotina*; all the parts of the mucosa adherent to the uterine walls not in the area of the serotina constitute the *decidua vera*; *ch*, chorion, within which is the embryo enclosed in the amnion, and attached to the walls of the chorion; appended to the embryo is the long-stalked yolk sac; the chorion is covered in by the arching extension of the mucosa, which is the *decidua reflexa*, *r*, *r*.

It is customary to describe the decidua as consisting of three portions: the general lining of the cavity of the uterus—the decidua vera; the portion immediately beneath the ovum—decidua serotina; and the portion surrounding the ovum and shutting it off from the rest of the uterine cavity—the decidua reflexa (Figs. 1577 and 1578). The terms reflexa and serotina date from the time of William Hunter. In the explanatory text to his Atlas, which was edited by his brother John and Matthew Baillie, it was stated that the decidua represented a fibrinous exudate from the lining membrane of the uterus, which formed a complete cast of its cavity and completely covered the tubal openings. Accordingly, when the fertilized ovum reached the uterine end of the tube, it found its passage opposed by the decidua vera, which it was obliged to invaginate before it in order to gain access to the uterine cavity, whence the term "reflexa." By the pushing forward of this structure, the portion of uterus behind it became denuded of decidua, and a new membrane was developed at that point, which was designated as the new or serotinal decidua, to which the ovum became attached.

This conception of the decidua was maintained until 1840, when Weber and Sharkey demonstrated that it contained glandular structures, which they identified with uterine glands. This being the case, it became necessary to explain the formation of the decidua reflexa in a different manner, and it was suggested that the ovum, upon reaching the uterus, found its entire cavity lined by decidua vera, to which it became attached at a point somewhere in the neighborhood of the fundus. Immediately afterward the vera began to proliferate and form a wall around the ovum, which gradually increased in height until it completely encapsulated it. Notwithstanding this change of view, the terms reflexa and serotina were retained until 1895, when His suggested that they be replaced by the terms capsularis and basalis respectively.

We are indebted to the work of Hegar and Maier, Friedländer, and Kundrat and Engelmann, for our earlier knowledge concerning the microscopical structure of the decidua vera. Friedländer, in 1870, pointed out that it was composed of two layers: a compact layer adjoining the uterine cavity, and a spongy or glandular layer adjoining the muscular wall of the uterus, the latter making up the greatest thickness of the membrane. He showed that the former was composed of large, round, oval, or polygonal cells, with large, lightly staining vesicular nuclei—the decidual cells; while the latter was made up of the dilated and hyperplastic uterine glands (Fig. 1579).

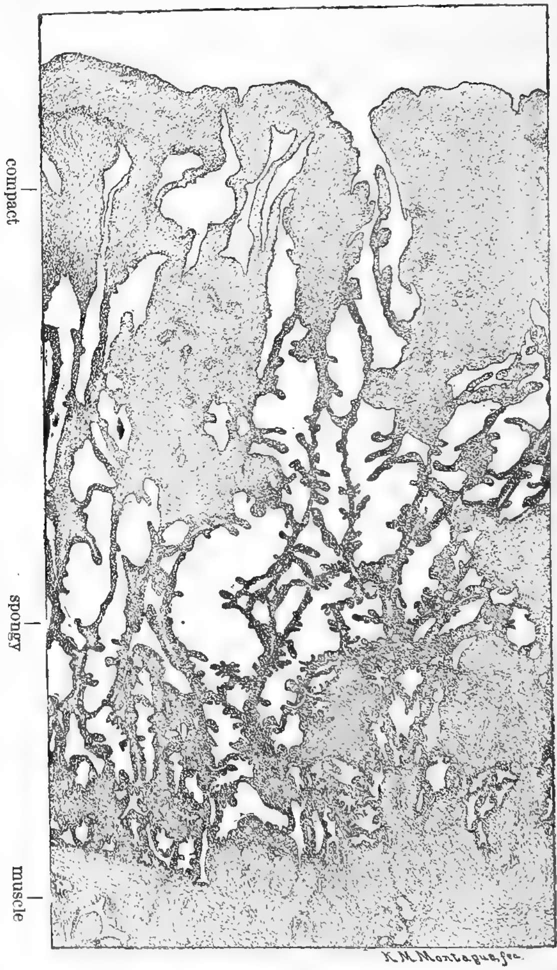

FIG. 1579.—Decidua Vera, Fourth Month. × 16. (From Author's "Textbook of Obstetrics," Appleton & Co., New York, 1901.)

The decidua vera increases markedly in thickness during the first few months of pregnancy, and by the end of the fourth month has attained a thickness of 8 to 10 mm. After this period, owing to the marked increase in the size of the uterus, it gradually becomes thinner, so that at the end of pregnancy it is rarely more than 2 mm. thick. Under the microscope the compact layer is seen to be made up of large, round, oval, or polygonal cells, which are distinctly epithelioid in appearance, and possess round, vesicular nuclei which stain but lightly with the ordinary reagents (Fig. 1580). When the tissue has been spread apart by hemorrhage or œdema, or in teased specimens, it is seen that many of the cells present a stellate appearance, and are supplied with long protoplasmic processes which anastomose with similar processes from neighboring cells. In the early months of pregnancy the compact layer is traversed by the ducts of the uterine glands, which, however, gradually disappear, all trace of them being lost after the third or fourth month.

The spongy layer is formed by the distended and hyperplastic glands of the endometrium, which are separated from one another by a minimal amount of stroma. In a good many instances the glandular hyperplasia is so marked and the glands assume such irregular shapes that this layer suggests an adenoma in appearance. And on several occasions I have seen competent microscopists diagnose adenocarcinoma of the body of the uterus from the normal scrapings obtained by curetting the pregnant organ.

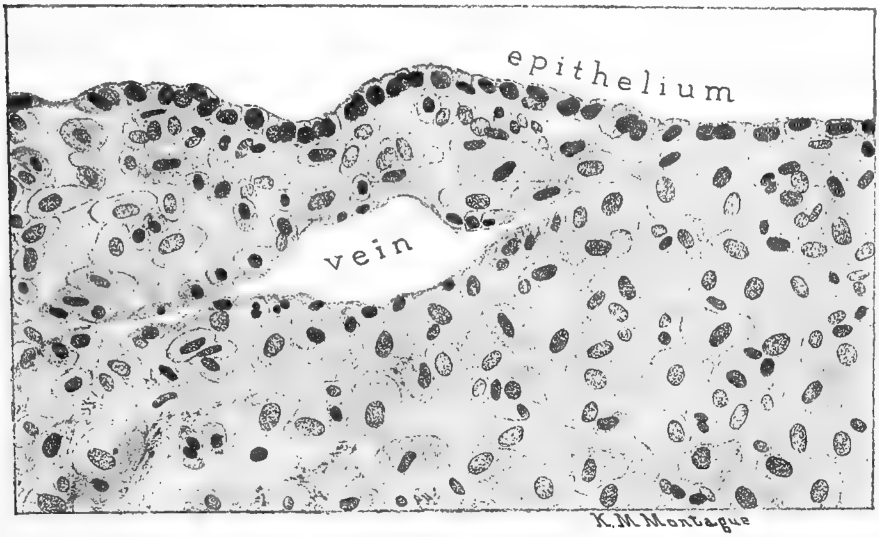

Fig. 1580.—Section through Compact Layer of Decidua. × 420. (From Author's "Textbook of Obstetrics," Appleton & Co., New York, 1901.)

In the early months, the glands of the spongy layer are lined by a single layer of characteristic cylindrical epithelium. This gradually becomes more cuboidal in shape and undergoes fatty degeneration, and is cast off in great part into the lumina of the glands, though a small part of it remains intact throughout pregnancy, and from it the endometrium is regenerated after labor. In many instances the formation of decidual cells is almost entirely limited to the compact layer, while the stroma between the dilated glands closely resembles that of the non-pregnant uterus.

Klein directed attention to the fact that the epithelial cells covering the surface of the decidua gradually lose their cylindrical shape and become cuboidal and even flattened, and sometimes resemble endothelial cells. He considered this condition quite as characteristic of pregnancy as the development of the decidual cells themselves.

Fig. 1580 represents a section through the compact layer of the decidua vera at the fourth month, and Fig. 1581 a section through a gland and its surrounding stroma from a non-pregnant uterus, drawn under the same magnification; and on comparing them it is readily seen that the decidua differs from the non-pregnant endometrium by a marked increase in the size of the stroma cells, and a marked decrease in the size of the epithelial cells.

As a result of the work of Hegar, Maier, Leopold, Minot, and many other observers, it is now generally admitted that the decidual cells are derived from the stroma cells of the endometrium, and are therefore of connective-tissue origin. The change consists of an hypertrophy of the pre-existing cells, rather than an actual increase in their number.

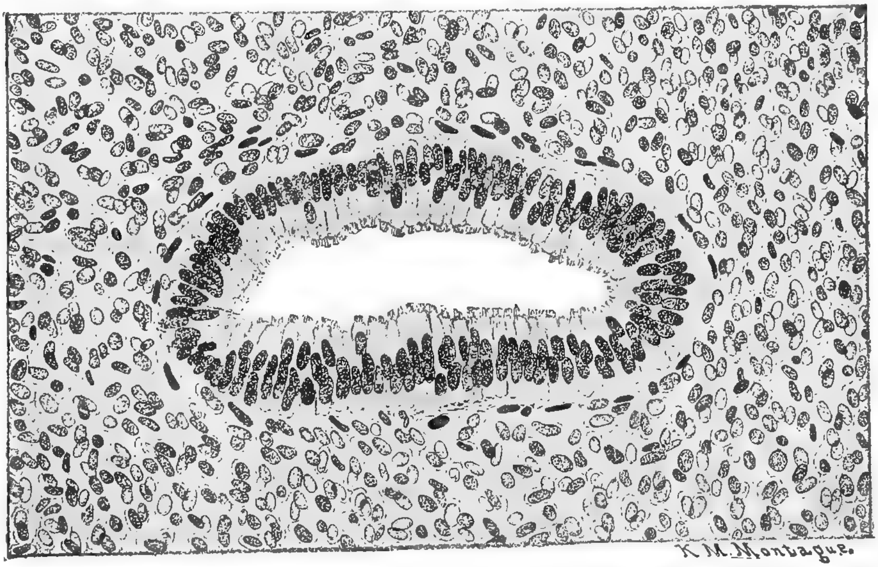

Fig. 1581.—Section Showing a Gland and Surrounding Stroma from a Non-Pregnant Uterus. × 420. (From Author's "Textbook of Obstetrics," Appleton & Co., New York, 1901.)

The connective-tissue origin of the cells in question was still further confirmed by finding that similar cells are formed in the stroma of the folds of the tube in tubal pregnancy, and in the subperitoneal connective tissue in normal pregnancy. For Schmorl, Kinoshita, and others have shown in women dying just after childbirth that the peritoneum covering the posterior surface of the uterus, Douglas' cul-de-sac, and the anterior surface of the rectum, is frequently studded by small nodules, some of which are just visible to the naked eye, while others are 1 or 2 mm. in diameter, which are composed of cells which do not differ from the decidual cells in appearance, and are undoubtedly derived from the subperitoneal connective tissue.

Before their true nature was definitely demonstrated, various theories were advanced as to the origin of the decidual cells. Hennig and Langhans believed that they were derived from leucocytes; Frommel and Overlach, from the uterine epithelium, and Ercolani, from the endothelium of the blood-vessels; but at present these views are of interest only from an historical standpoint.

Decidua Reflexa.—Except for the first few hours after its entry into the uterus, the ovum is completely shut off from the rest of the uterine cavity by the decidua reflexa, which forms a distinct capsule around it. In the early months of pregnancy, this structure does not completely fill the uterine cavity so that a space of varying size exists between the vera and the reflexa. But after the fourth month the reflexa, distended by the growing ovum, comes in contact with the vera, so that the uterine cavity becomes completely obliterated. In a short time the two structures fuse together, after which the reflexa gradually degenerates and disappears. This view was first advocated by Minot, and appears to be well founded, for sections through the wall of the full-term uterus outside of the placental site show that the entire decidua is only from 2 to 3 mm. thick, and in it no trace of the reflexa can be discovered (Fig. 1582).

The reflexa usually attains its greatest thickness at about the second month, when it is from 2 to 3 mm. thick. Sections through it at this time show that it is made up of typical decidual cells, and is covered on its exterior by a single layer of flattened or cuboidal epithelium; while its interior is in contact with the villi of the chorion læve, and at no time shows any trace of epithelium. In its lowest portion, where it is connected with the vera, an occasional gland may be found, and when their ducts are present they are seen to be open only upon the exterior of the membrane.

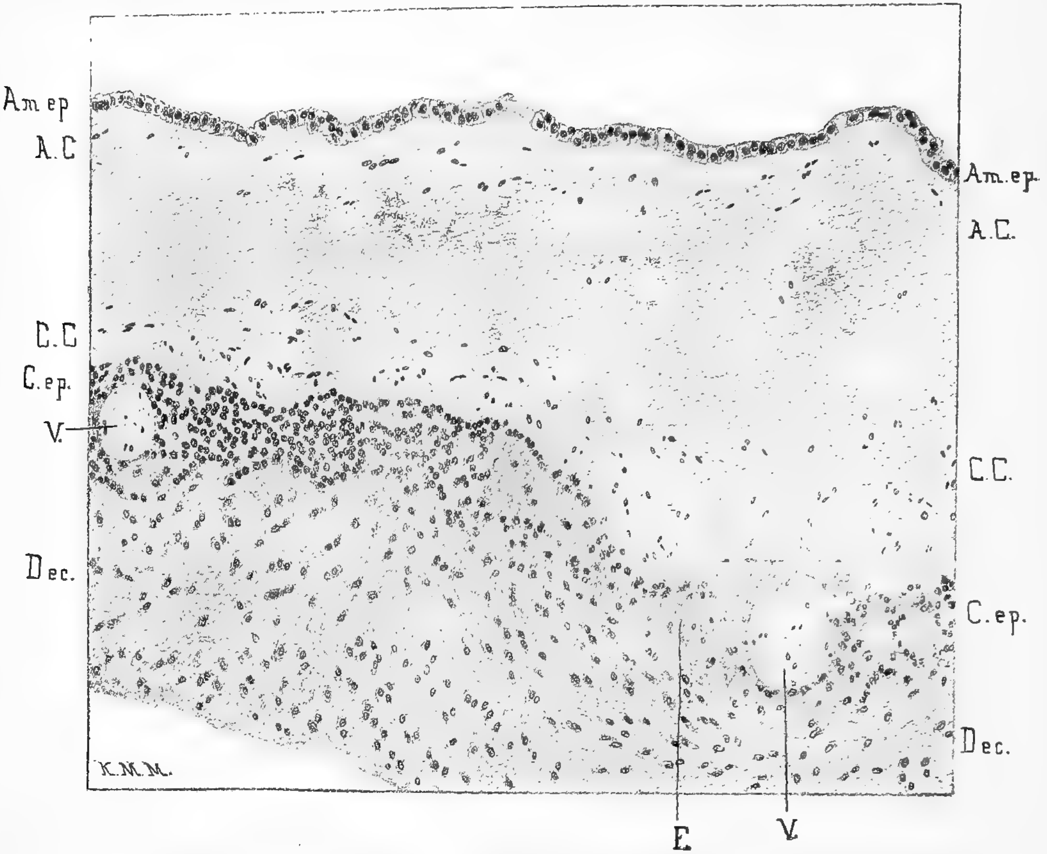

FIG. 1582.—Decidua and Membranes Outside of Placental Site. *Am.ep.*, Amniotic epithelium; *A.C.*, amniotic connective tissue; *C. C.*, chorionic connective tissue; *C. ep.*, chorionic epithelium; *Dec.*, fused decidua vera and reflexa; *V.*, degenerated chorionic villi.

Until very recently it was believed that the decidua reflexa was formed in the manner which I have already indicated. But Selenka pointed out that it was not so developed in monkeys and other animals; but that the ovum, immediately after its implantation upon the vera, penetrated the surface epithelium and sunk down into its stroma, and that therefore the reflexa was simply the portion of vera which covered the ovum. Peters, in 1899, described what he considered to be a three-days' human ovum in contact with the uterine wall, and clearly showed that it had burrowed down into the vera in the manner demonstrated by Selenka, and therefore concluded that the reflexa represented the portion of decidua vera which covers the ovum, and was not due to the proliferation of the vera, as was previously supposed (Fig. 1583). I have not had an opportunity to examine the pregnant uterus in its earliest stages, but in several very early cases of tubal pregnancy I have seen conditions which tend to confirm Peters' theory as to the mode of implantation of the ovum and the development of the decidua reflexa.

Decidua Serotina.—The decidua serotina is the portion of the decidua which lies immediately beneath the ovum and is in contact with the chorion frondosum, and it is by the union of the two structures that the placenta is developed, the chorion frondosum giving rise to its fœtal, and the decidua serotina to its maternal portion.

Generally speaking, the decidua serotina presents the same general structure as the vera, except that it never attains the same thickness, and rarely exceeds 3 mm. As pointed out in my article upon the *Chorion*, after the first few days of pregnancy it does not consist entirely of decidual cells, but is invaded by large numbers of cells derived from the trophoblastic layer of the ovum, and accordingly its superficial portions are composed of a mixture of decidual cells and fœtal ectoderm. On casual examination it is extremely difficult to distinguish between the two varieties of cells, but after more careful study, particularly when groups of cells are examined, their characteristic differences can readily be appreciated. Usually a layer of canalized fibrin occupies a part of the decidua serotina, and, as a rule, forms the boundary line between fœtal and maternal tissue; the tissue internal to it being composed almost entirely of fœtal ectoderm, with a slight admixture of decidual cells; while the tissue external to it is made up almost entirely of decidual cells with only isolated areas of fœtal tissue.

About the middle of pregnancy numerous giant cells may be distinguished in the deeper layers of the serotina. Friedländer and Leopold believed that they were derived from the decidual cells and made their way into the venous sinuses, and caused thrombosis. But more recent work tends to show that they are simply portions of syncytium which have wandered down into the deeper layers of the decidua and are therefore of fœtal origin.

One of the characteristic features of the decidua serotina is the presence of large numbers of blood-vessels. The arteries pursue a spiral course, and gradually lose their characteristic walls as they approach the free surface of the decidua, where they open into the intervillous spaces. The veins become markedly dilated, and form large venous sinuses, and careful examination of serial sections will show that they communicate by large funnel-shaped openings with the intervillous spaces.

In the third stage of labor the placenta and fœtal membranes become separated from the uterus and are cast off as the afterbirth. Microscopical examination shows that the fœtal surface of the placenta and the membranes is covered by a thin layer of decidual tissue, which corresponds to its compact layer and the upper portion of the spongy layer, and that the separation takes place in the upper portion of that layer, all above it being cast off with the afterbirth, and all below it being retained in the uterus. During the first few days of the puerperium the greater portion of the spongy layer, which has remained in utero, is cast off with the lochia, and only its deepest portion remains behind, from the epithelium of which the new endometrium is regenerated.

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Schmorl: Ueber grosszellige (decidua-ähnliche) Wucherungen auf

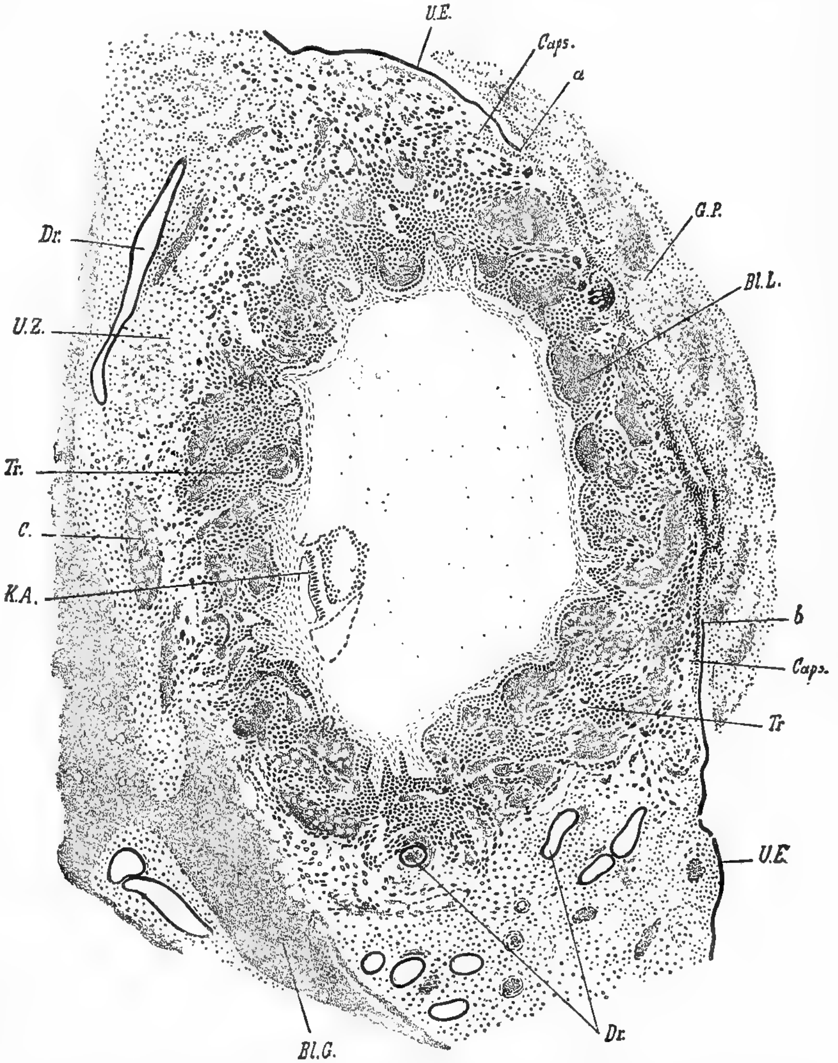

FIG. 1583.—Peters' Three-day Ovum. *U.E.*, Uterine epithelium; *G.P.*, fibrinous plug; *Dr.*, uterine glands; *Caps.*, decidua reflexa; *Tr.*, trophoblast; *Bl. L.*, blood spaces; *K.A.*, embryonic area.

dem Peritoneum u. den Ovarien bei intrauteriner Schwangerschaft. Monatsschr. f. Geb. u. Gyn., v. 46, 1897.
Selenka: Studien über Entwicklungsgeschichte der Thiere, Heft 5, Wiesbaden, 1891.
Sharkey: English translation of Müller's Handbuch der Physiologie, according to Schroeder's Lehrbuch, xiii. Auf., 1899.
Weber: Zusätze vom Bau und den Verrichtungen der Geschlechtsorgane. Abh. der kgl. sächsichen Akademie, 1846.
von Weiss: Zur Kasuistik der Placenta prævia centralis. Centralbl. f. Gyn., 641–49, 1897.

DECIDUA. (PATHOLOGY.)—The pathological changes occurring in the decidua during the course of pregnancy are but little known, although they play a very important part in the production of abortion and in various pathological conditions of the fœtus. The majority of the decidual changes which have been described as pathological have been in reality physiological phenomena. It must be borne in mind that the decidua, as well as the chorion, is to be regarded in the latter months of pregnancy as a senile structure which presents various evidences of physiological degeneration. Many of these, such as fatty degeneration, calcification, thrombosis, etc., have been mistaken for signs of disease, and the literature of decidual pathology is largely made up of such misconceptions. The true pathology of this membrane remains for the greater part an unexplored field.

Physiological Changes.—As in the case of the chorion, the earliest changes of senility occur in the vessels. As early as the seventh month large thrombi are formed in the sub-placental sinuses. These grow slowly toward the serotina and the intervillous spaces, but rarely extend far into the latter. The number of sinuses thus thrombosed is always relatively small under normal conditions. Giant cells are usually found in the veins so affected, appearing as early as the fifth month. These may be few in number or may completely fill the lumen of the vessel. Friedländer regarded these giant cells as being of decidual origin and entering the sinuses by diapedesis. After entrance into the vessels he believed that they adhered to the endothelium and induced the thrombosis. Further, he held that the progressive stagnation of the blood in the maternal sinuses led to a deficient oxygenation of the fœtal blood which became the exciting cause of the onset of labor. Other writers believe that the giant cells arise either from the syncytial layer of the chorion, or from the endothelium of the sinuses. During the latter months of pregnancy there is a proliferation of the intima in many of the sub-placental vessels leading to the gradual obliteration of a certain number of the sinuses, even before the beginning of labor. Since the sub-placental sinuses are as much temporary structures as is the placenta itself, they are unnecessary after labor; and like the placenta, they begin to show signs of their disappearance and decay as early as the seventh month.

Aside from the thrombosis occurring in some of its cavernous spaces, the deeper layer of the serotina does not show much change in the last months. Its cells are somewhat smaller than in the earlier stages, and are more closely packed together. Scattered areas of fatty degeneration are found in them. The upper compact layer shows more change. Its nuclei have largely disappeared, and the cell outlines are indistinct. With ordinary stains it is difficult to distinguish the boundary line between the decidua and the overlying fibrin deposit; but with Weigert's fibrin stain the necrotic cells of the uppermost layer are shown to be surrounded and separated from each other by a delicate line of fibrin. The source of this intercellular fibrin is not yet clear, though it is claimed by many to be a product of the cell degeneration. Simple necrosis, liquefaction, fatty degeneration, and a colloid-like change may all be found in the decidual cells of the upper layer and in those of the processes extending into the chorion. The fatty degeneration of the decidua is often visible to the eye as small whitish areas. Lime salts are not infrequently deposited in such degenerated cells. Small areas of leucocyte infiltration are occasionally seen scattered throughout the lower portion of the compact layer. They are, however, much less numerous than in the young serotina. The degenerative changes are most marked in the superficial layer of cells, which may be almost entirely replaced by fibrin. Beneath this the change is less advanced, and well-preserved decidual cells may be seen. It is apparent from the careful study of these changes that they begin in the most superficial layers, and gradually extending deeper involve the whole of the compact layer. On the serotinal surface there lies usually a thick layer of fibrin derived from the maternal blood. The superficial cells of the decidual processes extending into the chorion suffer a similar necrosis, and there is a formation of fibrin about and between them. The cells in the inner portions of these processes undergo a liquefaction necrosis, resulting in the formation of cystoid spaces filled with a finely granular material.

It is evident that the degeneration of the compact layer of the serotina is coincident with the thrombosis of the sub-placental sinuses, and that the two processes advance together, increasing toward term. In the last stages the placental arteries, as well as the venous sinuses, become obliterated or obstructed, and the degeneration of the serotina advances most rapidly during this time. There can be no doubt that the decidual degeneration is brought about by these vascular changes in the same way that chorionic infarction is dependent upon the changes in the chorionic vessels. It is to be noted, however, that in the chorion the small arteries are first affected, while in the case of the serotina the primary and chief changes are in the venous sinuses. The non-fibrinous infarct of the chorion may possibly be explained by the late thrombosis of the placental arteries. As a result of such thrombosis a portion of the intervillous spaces are deprived of blood, and the neighboring villi are crowded together to such a degree as to obliterate the intervillous spaces and to obstruct the circulation in the vessels of the villi. These changes lead to necrosis of the affected villi without an intervillous formation of fibrin.

Circulatory Disturbances.—The condition of the circulation in the sub-placental vessels and serotina is largely dependent upon the general state of the maternal circulation. In anæmias and various forms of general hyperæmia of the mother the circulation in the maternal placenta will show a similar condition. Local anæmia and congestion of the placental arteries and sinuses may be the result of partial obstruction or obliteration of certain of the vessels, or they may be secondary to pelvic or portal congestions. Hemorrhage from the decidua is of frequent occurrence. It may follow the death of the fœtus and the subsequent detachment of the placenta, or it may be the exciting cause of such detachment. It is in many instances impossible to fix the true relation existing between hemorrhage and abortion. The causes of decidual hemorrhage are manifold: trauma, external violence, mechanical attempts at abortion, maternal congestions, thrombosis of placental sinuses, rupture of the blood spaces of the serotina, excessive heart action, syncope, maternal albuminuria, syphilitic changes in the decidua, decidual hyperplasia, endometritis decidualis, etc. Large hemorrhages into the decidua may occur during labor. These are especially dangerous in the case of placenta prævia. In the early months of pregnancy the hemorrhage is most frequently due to rupture of the thin-walled blood-vessels surrounding the chorionic villi. The large collections of blood and blood clot found so frequently in the intervillous spaces, the so-called "placental apoplexy," are not in reality a hemorrhage since the blood lies in a blood space. In many cases the condition represents only an extreme congestion of a portion of the intervillous spaces, while in others the collection of blood may be due to a true hemorrhage into the intervillous spaces arising from ruptured vessels in the serotina. Some of the so-called "red infarcts" are apparently formed in a similar manner. Occasionally extravasations may burrow down between the layers of the decidua and escape from the uterus. The effects upon the fœtus will depend upon the amount of blood extravasated. In large hemorrhages the villi may be compressed and the fœtus asphyxiated, or the placenta may be partially or wholly stripped from the uterine wall, and the fœtus prematurely expelled. Smaller hemorrhages may lead to disturbances of fœtal development without causing its death. Such an extravasation may become organized, partly absorbed, or encapsulated. In the latter case the liquefaction of the clot gives rise to a cyst which contains either a red, or a brown, or a clear fluid.

After the death of the fœtus the placenta may be retained for a long period of time. If hemorrhages occur into the membranes with clotting of the blood thick deposits of fibrin may be formed on and between the layers, leading to the production of a flesh-like mass which is known as *fibrin mole* or *fleshy mole.* The formation of such a mole may begin before the death of the fœtus, and may be the exciting cause of abortion. If the dead fœtus is not expelled it may be absorbed; after this the growth of the fœtal membranes may continue with or without successive hemorrhages. In the latter case a solid flesh-like cast of the uterine cavity, made up of fibrin and remains of the fœtal membranes, may ultimately be expelled. A similar process may take place in the case of retained placenta after delivery at full term, but it is of most frequent occurrence in the earliest stages of pregnancy.

Retrograde Changes.—Atrophy of the decidua has been described, but is of rare occurrence. Either the decidua serotina, or vera, or reflexa may show this change, singly or coincidently. As a result of such atrophy the ovum may be attached to the uterine wall by a slender pedicel, which may become so stretched that the ovum comes to lie in great part within the cervical canal. In other cases its membranes may rupture and its contents be discharged from the uterus. The changes taking place in the atrophic membrane are similar to those occurring in the decidua reflexa in the physiological atrophy of this portion of the decidua in the latter months of pregnancy. The retrograde changes, such as fatty degeneration, necrosis, calcification, etc., which occur as physiological changes in the last months, may have pathological significance when they appear at an earlier period or are more extensive than usual. They are usually the result of a premature thrombosis of the sub-placental sinuses, and are found especially in connection with maternal syphilis, nephritis, and other cachexias. Local inflammatory changes in the endometrium, hyperplastic conditions of the decidua, etc., likewise lead to a premature degeneration of the serotina. These changes when extensive and when they occur at an early stage of pregnancy may lead directly to death of the fœtus and abortion, but, as a rule, they give rise to hemorrhages which become the direct exciting cause of abortion. Pathological fatty degeneration never occurs in the decidua to any great extent, though slight degrees of this change are almost constantly present in the physiological decay of this membrane. Necrosis—both the simple form and liquefaction necrosis—is the most common retrograde change found in the decidual membranes. By many writers the death of the decidua is regarded as being more of the nature of a coagulation necrosis in which fibrin is formed from the degenerating decidual cells. It is, however, more probable that the fibrin is derived from the maternal blood, being formed upon and between the cells, so that the necrosed cells come to lie in a network of fibrin which completely replaces the intercellular substance. The cells themselves do not stain like fibrin, but in the majority of cases have a hyaline appearance and stain in a manner similar to colloid (so-called hyaline degeneration). As the intercellular fibrin contracts the cells become smaller and gradually disappear. Premature necrosis of the superficial layer of the serotina occurs, especially in syphilis acquired during the early months of pregnancy and in albuminuria. Calcification rarely is extensive enough to possess pathological significance, but occurs more frequently in syphilis, albuminuria, etc. Deposits of blood pigment may occasionally be found as the remains of old hemorrhages.

Progressive Changes.—Hyperplasia of the decidua not infrequently occurs in the form of diffuse or circumscribed thickenings. The latter are most common, and are usually associated with chronic endometritis. The general thickening occurs in association with defective development of the fœtus. Nodular and diffuse fibrous thickenings have also been described. The physiological atrophy and blending of the decidua reflexa with the vera may not take place, and the former remains as a distinct and thickened membrane. These changes are considered by many writers to be of inflammatory origin. Hemorrhages and various retrograde changes are usually associated with the different forms of hyperplasia.

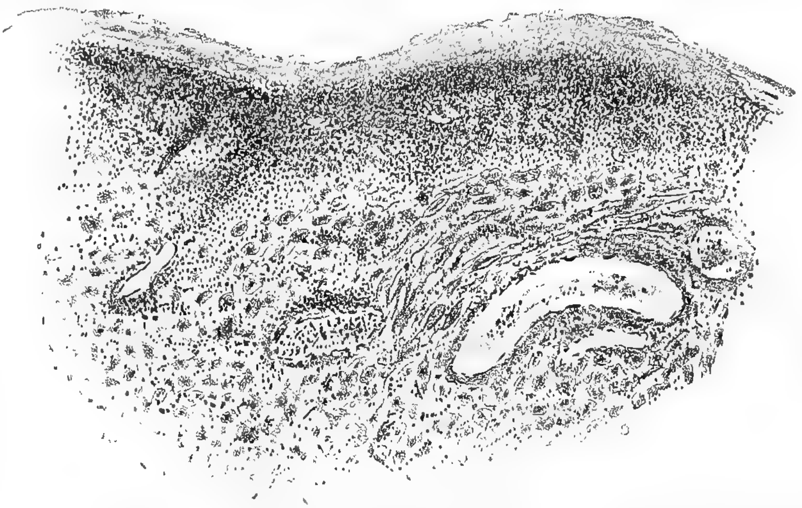

FIG. 1584.—Endometritis Deciduæ. Marked small-cell infiltration of the uppermost layers of the decidua. (After Gebhardt.)

Inflammation.—In the early months of pregnancy small areas of leucocyte infiltration are very frequently found in the lower layer of the serotina. In the later stages of development they are less common. Purulent inflammation of the decidua during the course of pregnancy is not of rare occurrence. It may be the result of gonorrhœal infection or of infection with pyogenic organisms following attempts at abortion or during prolonged labor. In these cases pus may be formed in the serotina and vera as well as in the chorion; a thin layer of pus covering the entire vera is sometimes found. The small-cell infiltration is found usually only in the superficial layer, while at a greater depth only isolated collections of leucocytes are seen. Acute inflammation of the decidua may occur in the course of cholera and other infections, especially in the exanthematous diseases; also, following attempts at abortion, trauma, etc. In cholera the decidua may be thickened, of a dark purple color, and contain numerous extravasations of blood (endometritis decidualis hæmorrhagica). It is probable that the same condition may be found in other acute infections. In the exanthemata premature expulsion of the fœtus not infrequently occurs at the time of the appearance of the eruption, and this has been explained by Klotz as being the result of an exanthematous inflammation of the endometrium and decidua.

The chronic forms of decidual inflammation are more frequently seen. They partake more of the nature of hyperplasias than of true inflammatory processes. They form the most common pathological condition of the placenta, and are the most frequent cause of abortion. In general, they are characterized by an overgrowth of the decidua or some of the constituent elements of the endometrium. The origin is almost always from a pre-existing endometritis, of either gonorrhœal, or syphilitic, or non-infective nature. In some cases the death of the fœtus may be the exciting cause, the decidual changes being secondary to this event. Five forms of chronic decidual endometritis occur: the diffuse, polypoid, catarrhal, adenomatous, and cystic. In the diffuse form there is an increase in all of the elements of the decidua leading to the formation of a membrane many times thicker than the normal decidua. In the case of rapid hyperplasia death of the embryo may occur as the result of deficient nutrition, or extensive hemorrhages into the hyperplastic decidua may take place, either separating the membrane from the uterine wall or breaking through it into the fœtal membranes. The embryo may be absorbed and the decidua and remnants of fœtal membranes, together with masses of fibrin, may be expelled later as a fleshy mole. If the hyperplasia is of slow development pregnancy may go on to full term, and a living child be delivered. Various evidences of deficient development are, however, very common in these cases. The hyperplastic decidua shows a great increase in the number of decidual cells, many of which are spindle-shaped, resembling connective tissue more closely than decidua. Areas of fibrous connective tissue are found throughout the membrane, and newly formed unstriped muscle is described as occurring. Either the cellular or the connective-tissue hyperplasia may predominate. If the latter takes place to a very marked degree the condition may be termed scirrhous inflammation of the decidua. The effects of chronic decidual endometritis upon both mother and fœtus are very important. The hemorrhages may prove fatal to the former as well as to the latter. After the expulsion of the fœtus portions of the hyperplastic decidua usually remain attached to the wall, and, these continuing to grow, may either give rise to further hemorrhages or to the development of a malignant tumor, or through decomposition produce toxæmia, or lead to infection.

In the polypoid form there is in place of the diffuse thickening a localized hyperplasia in the form of scattered nodules or outgrowths (endometritis decidualis polyposa s. tuberosa). On the inner surface of the decidua there are villous-like projections 2 to 5 cm. in length, very vascular, and having a smooth surface. Between these may be seen the openings of the uterine glands, many of which are greatly dilated. The entire membrane is thickened, and there is an apparent new formation of blood-vessels. On microscopical examination the outgrowths are found to consist of decidual cells, many of which are larger than usual and possess very large nuclei. Bands of connective tissue are found throughout the membrane, especially about the glands and blood-vessels. This form occurs only in the early stages of pregnancy, and is frequently associated with a myxomatous degeneration of the chorion. Abortion usually occurs before the fourth month. Syphilis was formerly supposed to be the cause of this disease, but it is found in cases of chronic endometritis in which no syphilitic history can be obtained. The gonococcus has been found in a number of cases.

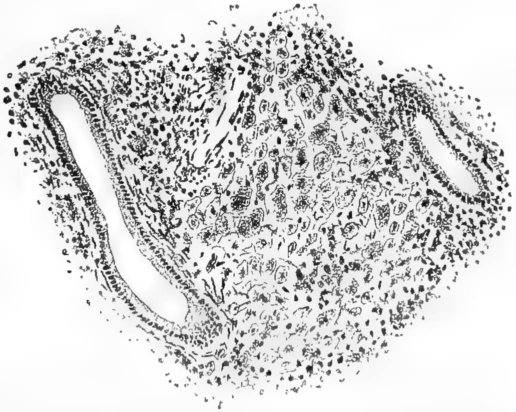

FIG. 1585.—Subinvolutio Deciduæ. An island of decidual cells in the midst of tissues of the endometrium which have undergone complete involution. (After Gebhardt.)

A catarrhal endometritis may either prevent conception or hinder the development of the fertilized ovum in the uterus through deficient formation of the decidua. The vera and reflexa may fail to unite, and the serotina may be very small or attached to the ovum in the form of a pedicel. The catarrhal secretion of the uterine glands in the shape of a thin, watery mucus may collect between the vera and reflexa, preventing their union (hydrorrhœa gravidarum). This fluid may be expelled from the uterus in sudden gushes, or it may dribble away for a long time without seriously affecting the course of pregnancy. If a large quantity of fluid collects uterine contractions are usually set up and abortion results. The condition is rare, occurring more frequently in multiparæ, and begins usually in the third or fourth month.

The adenomatous form of decidual endometritis takes its origin from cases of chronic glandular endometritis. With the beginning of the formation of the decidua there is at the same time a glandular hyperplasia which may be so marked as to assume the character of an adenoma. It may be general or localized. This change takes place very early, and leads very quickly to abortion. The endometrium is greatly thickened; on microscopical examination the surface of the endometrium is seen to consist of a thin layer of decidua beneath which lie the hyperplastic uterine glands. The latter are greatly enlarged and increased in number with but little intervening stroma, so that the appearance of an adenoma is presented. A similar condition occurs in the case of retained decidua after abortion or delivery, very frequently in cases of subinvolution. If there is an excessive secretion in the glands, and if this be prevented from escaping, cystic dilatation of the gland spaces may result (endometritis decidualis cystica). In these cases the decidua is thickened from an increase of decidual cells, connective tissue, and fibroblastic tissue. Numerous small cysts are scattered through it, corresponding to the dilated glands. The cystic form is found only in the early stages of pregnancy, but it is probable that it precedes the diffuse hyperplastic form, the glands being obliterated as the process advances.

The prognosis in all forms of chronic decidual endometritis is very unfavorable for the fœtus, and not wholly favorable for the mother. The disturbance of fœtal nutrition and the tendency to hemorrhage render the chances of escape from abortion very slight. As a result of the firmer attachment of the decidua to the uterine wall, retention of the membrane after abortion or delivery is especially likely to occur; and in this lies the source of greatest danger to the mother in the form of repeated hemorrhages and infection following the necrosis of the retained material. Treatment during pregnancy is of course impossible. Since the cause of these chronic forms lies in a pre-existing chronic endometritis their prevention should be attempted through the cure of the latter. The gonococcus is probably the most important etiological factor, either directly or by paving the way for secondary infections. The treatment of gonorrhœa will be, therefore, the chief means of prevention of these conditions.

Endometritis Decidualis, Post-Abortum s. Post-Partum (*Retentio deciduæ, Subinvolutio deciduæ*).—After normal termination of pregnancy the decidua undergoes an involution into the normal uterine stroma. This involution under normal circumstances progresses uniformly over the entire endometrium. Under certain conditions, the causes of which are as yet unknown, portions of the decidua fail of involution and retain their character long after the expulsion of the fœtus and placenta. This is of much more frequent occurrence after abortion, in which case portions of the chorion are usually retained. Persistence of the decidua may, however, occur without retention of the fœtal membranes, though this is questioned by some writers. On the other hand, retention of the chorion is always associated with persistence of the decidua. Though the name retentio deciduæ has been applied to this condition, it is properly a subinvolution and not a retention, as under normal circumstances the entire decidua is not expelled from the uterus but becomes changed back into uterine stroma. To the naked eye the endometrium shows but little change in some cases, but often it is diffusely or irregularly thickened, and may present a polypoid appearance. Under the microscope two different forms may be distinguished, but these are frequently combined. In the first form, groups of large decidual cells are found scattered through the stroma of the endometrium which has resumed its normal character. The cells in the central portion of the groups are the largest, and best preserve their decidual characteristics, while those at the periphery are smaller and pass gradually into the surrounding stroma tissue so that no definite point of transition can be made out. The groups of decidual cells lie for the greater part in the upper layers of the endometrium, but are covered by surface epithelium from which they are separated by a more or less thick layer of stroma. This form of retention of the decidua is distinguished from those forms of chronic endometritis in which the stroma cells increase in size and more or less resemble the decidual cells, by the fact that the true decidual cells lie in groups and are not diffusely scattered throughout the entire endometrium. In the second form the decidual cells lie in the lower portion of the endometrium, extending even into the muscle and into the walls of the blood-vessels. This form is easily distinguished from the changes of chronic endometritis by the relation of the decidual cells to the large blood-vessels, as in chronic endometritis changes of this kind do not take place. In both forms of retentio deciduæ the endometrium shows either a glandular or an interstitial inflammation. In many cases it becomes impossible to decide as to which is the primary process. The frequent and severe hemorrhages which form the chief symptoms of retention cannot be explained by the microscopical findings. In the early stages of retention of the fœtal and decidual membranes infection with saprophytic or pyogenic organisms is likely to occur, giving rise to either putrid or septic inflammatory processes (endometritis puerperalis putrida s. septica). The putrid form is caused by various anaërobic bacteria, the Proteus vulgaris, colon bacillus, etc.; the septic form is dependent chiefly upon the streptococcus and staphylococcus. The latter condition not infrequently assumes the character of a diphtheritic inflammation.

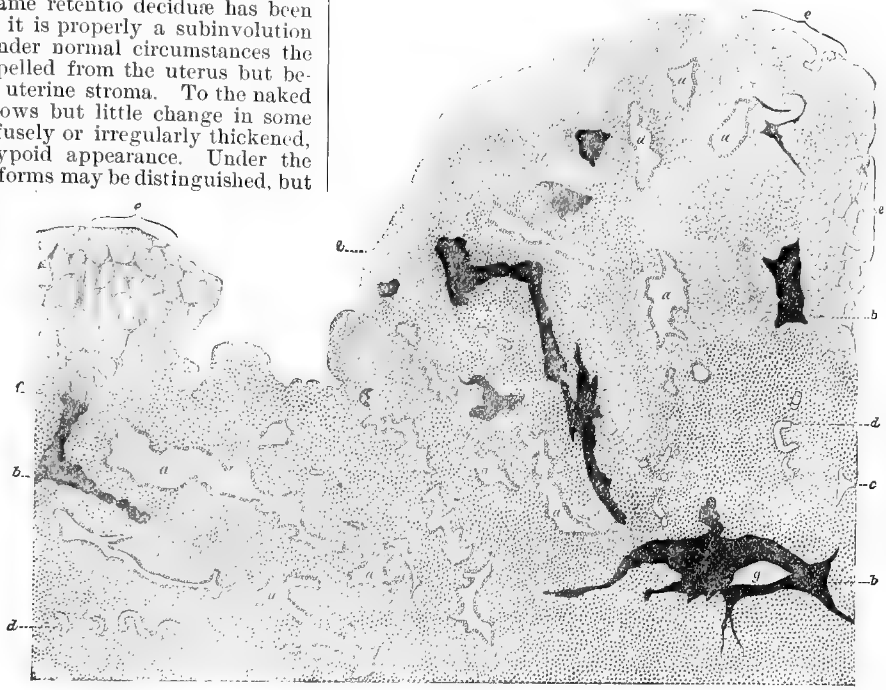

FIG. 1586.—Benign Deciduoma; Section of Periphery of Tumor. *a*, Glands; *b*, blood spaces; *c*, lymph sinus; *d*, arteriole; *e*, capillaries; *f*, junction of capillaries and blood space; *g*, island of decidual tissue in blood space. (After Klotz, *Arch. f. Gyn.*, vol. xxix.)

Tuberculosis.—Tubercle bacilli have been demonstrated in the placental sinuses when no tuberculous lesions were present in the placental tissues. In the case of decidual formation in a tuberculous endometrium the tubercles may gradually invade the decidua and later the chorion. In acute miliary tuberculosis of the mother miliary tubercles containing numerous giant cells may appear in the serotina and later extend into the decidual processes between the villi, ultimately involving the latter. As regards their formation and development decidual tubercles are in all ways similar to tubercles found elsewhere in the body. The lesion is probably of more frequent occurrence than is generally supposed.

Syphilis.—Almost all of the physiological changes, such as fatty degeneration, calcification, etc., have been ascribed to syphilis. The changes in the sub-placental sinuses have likewise been considered to be due to the same cause. There is, however, no definite relation between the occurrence of these changes and syphilitic infection. They bear the same relation to nephritis and other cachexias, in that in all of these conditions they are more extensive than they should be normally. It is to be noted that in well-marked cases of syphilitic infection, both of mother and of child, no changes may be found in the decidua. Further, the syphilitic nature of many of the supposedly specific changes in the decidua is very doubtful. A diffuse hyperplastic endometritis serotina has been described. The decidua is thickened, cloudy, and yellowish in color, and its consistence is greatly increased. In its general character this form of decidual hyperplasia (endometritis decidualis syphilitica) cannot be distinguished from the hyperplastic form of decidual endometritis occurring without syphilis. It is probable that the relation is one of coincidence. A form of decidual hyperplasia associated with the development of gummata (endometritis decidualis gummosa) has also been described by a few observers. Throughout the hyperplastic decidua there are scattered miliary or larger nodules which have a caseating centre with a periphery of leucocyte infiltration or connective tissue. The larger nodules are for the greater part composed of firm connective tissue or granulation tissue, in the centre of which there is a finely granular detritus. It is probable that fibrin masses, placental infarcts, necrotic areas, etc., have been mistaken for gummata, as the descriptions given in some of the reported cases are not conclusive. In a general way the changes in the maternal placenta that can be ascribed to syphilis are of the same nature as those occurring in the fœtal placenta; they are of the character of senile changes occurring either prematurely or to a much greater degree than normally. Of these extensive thrombosis of the subplacental sinuses is the most important, as it gives rise to the retrograde changes in the serotina, and also most probably plays a part in chorionic infarction.

New Growths.—Hyperplastic conditions of the decidua are found in either a diffuse or a polypoid form, before or after the expulsion of the fœtus, but occurring most frequently in subinvolution of the decidua after abortion. They are also of frequent occurrence in the various forms of decidual inflammation either of specific or non-specific origin. To this class of simple decidual hyperplasia the majority of the so-called decidual polyps or benign deciduomata belong. It is doubtful if these should be regarded as neoplasms, but no distinct line of separation can be drawn between such simple hyperplasias and those whose overgrowth is so extensive as to warrant their being classed as tumors. They differ, however, from the true decidual neoplasms in that they are almost always spontaneously expelled, or undergo involution. If operated upon they do not recur, provided the removal has been complete. On the other hand, the true neoplasms arising from the decidua show a progressive growth, and do not tend to spontaneous expulsion or involution. Two forms of decidual neoplasms have been so definitely described that their position in oncology may be said to be securely fixed. The first of these is composed of decidual tissue and contains uterine glands or new glandular tissue derived from these. Its structure, therefore, resembles that of the serotina. This growth is analogous to the adenoma in its general manner of growth. It is benign, in that it does not produce mestastases, but may recur after operation if not thoroughly removed. It does not undergo spontaneous involution or expulsion, but shows a progressive growth for months after the abortion or delivery which gave it origin. In a few cases a much longer period, from one to two years, has been observed. The growth takes its origin from the islands of decidual tissue found in subinvolution of the decidua. To this form the term deciduoma has been usually applied, but the simple inflammatory hyperplasias, subinvolutions, etc., as well as the new growths arising from the chorionic epithelium, have also been called by this name. Much confusion has therefore arisen out of the unsettled state of the terminology of the neoplasms arising from the decidua and chorion. In the majority of the latest text-books the term deciduoma is used as a synonym for syncytioma, though the latter tumor arises from the syncytial layer of the chorion, is epithelial in character, and has nothing in common with the decidua, which is of mesoblastic origin. To clear up this confusion it has been suggested by Sänger that the term deciduoma be dropped, and the decidual neoplasm be known by the term, *decidual adenoma* or *adenoma deciduale.* It seems to the writer that this use of the word adenoma is also of danger in that a wrong conception of the structure of the decidual growth may be given, since the present use of the word adenoma is restricted almost wholly to epithelial tumors. In view of this it would seem better to retain the use of the word deciduoma, applying it only to this growth in the form of *deciduoma benignum.* Clinically, this growth is characterized by severe hemorrhages, secondary infections, etc. The

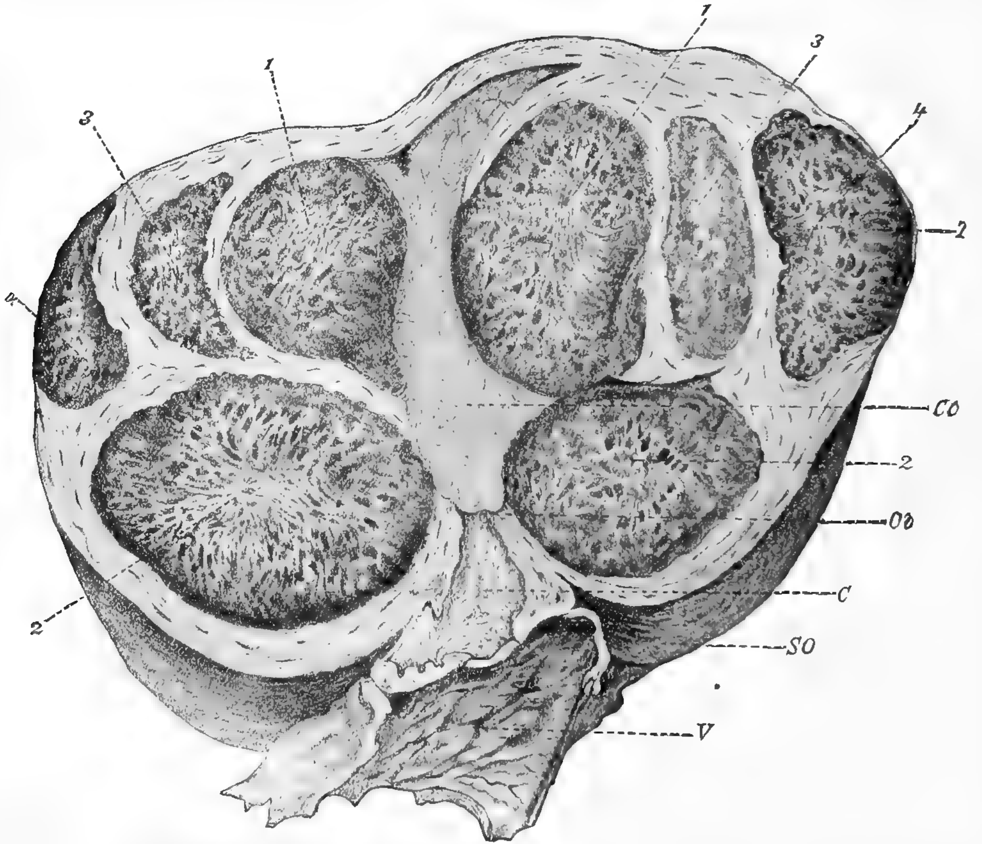

FIG. 1587.—Sarcoma Uteri Deciduo-cellulare. Uterus opened in the anterior median line, showing many tumor nodules (1, 2, 3, 4). *T*, Tumor; *Cc*, uterine cavity; *Oi*, internal os; *C*, cervix; *V*, vagina; *SO*, serosa of uterus. (After Sänger, *Arch. f. Gyn.*, vol. xliv.)

treatment consists of thorough and deep curetting. This will produce a cure, if malignant changes have not already taken place.

The second form of decidual neoplasm bears the type of a sarcoma and contains no glands. To it the names of deciduo-sarcoma or sarcoma deciduo-cellulare have been given. These terms express very satisfactorily the origin and character of the growth. This possesses the structure of a sarcoma, consisting of large oval or spindle-shaped cells with occasional giant cells, and having a very scanty intercellular substance. The cells bear a very close resemblance to decidual cells, and in some cases the origin of these cells from the decidua can be definitely made out. The tumor may form a diffuse growth over the endometrium or may develop scattered nodular masses. These frequently undergo ulceration. It may extend into the uterine wall by expansion or infiltration. Metastases are very quickly set up; these are most frequent in the vaginal walls and lungs. It is one of the most malignant forms of sarcoma on account of its rapid diffusion. Retention of the chorion with or without pathological changes in the chorionic villi may or may not take place in association with this growth. Clinically, this tumor is characterized by its development following delivery or abortion, severe hemorrhages, secondary infections, rapidly developing cachexia, evidences of metastases in lungs, etc., and very rapid course, the majority of the patients dying within six or seven months. The disease is very often mistaken for cancer or puerperal sepsis. The differential diagnosis must depend entirely upon the microscopical examination of portions of the growth removed from the uterus. Because of its very rapid growth a cure can be effected only by the earliest possible recognition of the condition and the removal of the uterus. The prevention of the growth may be accomplished by the complete removal from the uterus of all portions of retained placenta after delivery or abortion. This is of especial importance in the case of hydatid mole, since in many cases the decidual sarcoma appears to follow this condition.

Aldred Scott Warthin.

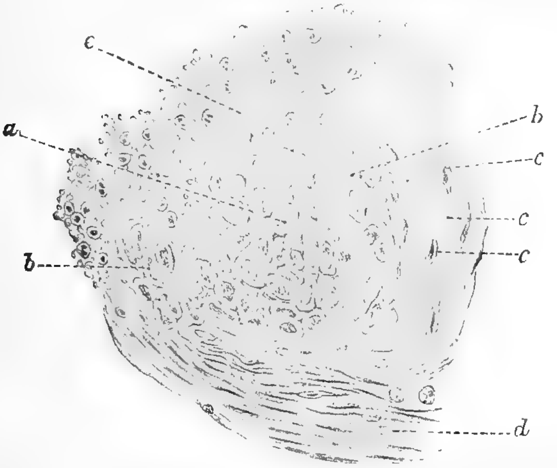

FIG. 1588.—Section of Tumor Nodule from Uterus Pictured in Preceding Figure (Sarcoma Uteri Deciduo-cellulare). *a*, Nest of decidua-like cells infiltrating muscularis; *b*, *b*, smaller nests; *c*, intermuscular connective tissue; *d*, muscle; *e*, hemorrhage. (After Sänger' *Arch. f. Gyn.*, vol. xliv.)

DECIDUOMA. See *Chorion. (Path.); Decidua. (Path.); and Syncytioma.*

DEEP ROCK SPRING.—Oswego County, New York.

POST-OFFICE.—Oswego. Hotel.

Oswego is located on Lake Ontario, about fifty miles south of the head of the St. Lawrence River. It is reached by the Delaware, Lackawanna and Western, Rome, Watertown and Ogdensburg, and the New York, Ontario and Western railroads. The Deep Rock Spring was opened to the public and the water placed on the market in the spring of 1871. Since that time it has had an extensive sale, competing fairly in the markets with the most popular waters of the time. The following analysis was made by Prof. Silas H. Douglass, of the University of Michigan:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	308.18
Potassium chloride	149.08
Magnesium chloride	10.24
Calcium chloride	18.19
Silica	71.70
Sulphuric acid	Trace.
Iron protoxide	Trace.
Loss	1.78
Total	559.17

Carbonic acid gas, not determined.
Temperature of water, 50° F.

The water is strongly saline and actively diuretic without cathartic effects. It is useful in rheumatism and some forms of kidney and bladder troubles. It is claimed that the water contains a greater proportion of potassium chloride than does any other known spring. A valuable sulphur spring has been discovered in a ledge of rocks fifty-seven feet above the source of Deep Rock, and it is intended to utilize this for both drinking and bathing purposes. The city of Oswego offers unusual attractions as a place of residence during the summer. The well-known Doolittle House, adjoining the springs, has accommodations for one hundred and fifty guests.

James K. Crook.

DEERS-TONGUE. See *Coumarin.*

DEFECATION.—The residue of food digestion and other débris from the alimentary canal, after accumulating in the colon and sigmoid flexure, are discharged at more or less regular intervals. This discharge constitutes defecation. The rectum is ordinarily a closed tube, the descent of fæcal matter into it being prevented by the so-called third or superior sphincter. Its distention by fæcal matter produces the normal stimulus to peristaltic contraction and a sensation which is recognized by the individual as a call for evacuation. If the call be not promptly responded to, the rectal contents pass back, probably by a reversed peristalsis, into the sigmoid flexure, and the desire for evacuation temporarily ceases. Ordinarily the call is repeated at short intervals and with increasing urgency until it is responded to; habitual neglect of it begets a tolerance, and the rectum becomes also a reservoir of fæcal matter, and its evacuation as a result becomes difficult.

From this it is evident that defecation is largely under the control of the will, but it is not wholly so. It is, in fact, a reflex, involuntary act, aided or prevented, as the case may be, by voluntary impulses. The extrusion of fæcal matter is accomplished chiefly through the peristaltic movement of the bowel, both longitudinal and circular muscular coats taking part in it. The contraction of the circular fibres produces the peristaltic wave, while that of the longitudinal fibres gives support to the rectum and tends to diminish its length. The anal orifice is guarded by two sphincters, the outer one a voluntary muscle, the inner involuntary, being formed by a strong band of the unstriated circular coat of the bowel. The external sphincter is composed of striated fibres; but it is only to a certain extent under control of the will, for it relaxes when the impulse to evacuate becomes imperative. The musculature of the rectum is under the control of both motor and inhibitory nerve fibres. Some of these fibres come from the lumbar plexus and others from the sympathetic ganglia of the region, the inferior mesenteric and the hypogastric plexuses. The physiological centre in the lumbar cord is known as Budge's centrum anospinale. There exists also a nervous connection with one or more cerebral centres. There is, undoubtedly, an inhibitory centre, supposed to lie in the optic thalami, whose action is in part at least to prevent the reflex closure of the sphincter under the stimulation of the sensory nerves of the rectum by the descent of fæces. In the infant defecation is probably entirely involuntary. In certain diseases of the brain or spinal cord, in sleep, or in intoxication, involuntary evacuation sometimes occurs, and certain psychic states, the disturbance of the emotions as by fright or fear, are capable of inducing it. Such accidents are attributable either to the removal of some cerebral control or to the action of the inhibitory centre.

Defecation begins ordinarily with the voluntary inhibition or withdrawal of the action of the external sphincter. This inhibition is of limited duration, however. It may be terminated voluntarily, but it cannot be continued indefinitely by the action of the will; a rather sharp contraction, as a rule, follows the passage of a fæcal mass. Relaxation of the sphincter is accompanied by a contraction of the abdominal muscles and a variable action of the diaphragm, corresponding to the amount of expulsive force required. The sensation produced by the distention of the rectum is peculiar and should not be disagreeable, but in some diseased conditions of the bowel it becomes exaggerated into a painful tenesmus. If the peristaltic action has been strong and the demand for evacuation imperative, the diaphragm is not necessarily brought into requisition, but when additional force is required, as in constipation, the diaphragm is depressed, causing full inspiration, and its ascent is prevented by a closure of the glottis. In this way and by the subsequent contraction of the abdominal muscles, not only is the rectum emptied, but the passage of the contents of the colon and sigmoid flexure into the rectum is assisted. Defecation is assisted also by the levator ani muscles, whose contraction tends to draw the sphincters upward over the fæcal mass. The rectal peristalsis can be increased also by repeated voluntary contractions of this muscle and the external sphincter. During defecation the mucous membrane of the anus is slightly everted, especially when the expulsive force is strong. After the completion of defecation the sphincters relax to some extent, as their contraction is not required to retain the closure of the anus in the intervals between the acts of defecation.

It is generally admitted that defecation should occur once in twenty-four hours, yet it may occur twice or thrice within that limit of time or only once in two or three days with apparently normal regularity. Its frequency is largely a matter of habit with the individual. In cases of habitual constipation evacuations may occur as seldom as once in a week, but in inflammatory diseases of the intestine they may occur at intervals of only a few minutes. The frequency and character of defecation are often valuable factors in diagnosis.

James M. French.

DEGENERATIONS AND DEPOSITS, PATHOLOGICAL.—Among the most important retrograde changes are those classed as the degenerations and the deposits. While the term tissue degeneration is very often loosely applied to all kinds of retrograde changes, it is also used in a specific sense to indicate that particular class of retrograde change which is characterized by the formation of new substances out of the cell protoplasm. These substances may be retained within the cell or discharged from it. Any pathological increase in the production of substances normally manufactured by the cell would be included under this head. To avoid the confusion arising from the loose use of the term degeneration, it might be of advantage to class these changes as the *true degenerations*. The *deposits* or *infiltrations*, on the other hand, are characterized by the deposit in the tissues of pathological substances which have either formed within the body or have been introduced into it from without. The deposit is often a result of degeneration either at the point of deposit or elsewhere in the body, or it alone may represent the chief feature of the pathological change. It is very difficult sometimes to draw a distinct line between degeneration and deposit, since identical or similar substances may be both formed within the cell out of its own protoplasm or be brought to it, and deposited either in it or about it. Some substances such as fat, melanin, glycogen, etc., thus play the rôle of both degeneration and deposit; while others such as mucin, pseudomucin, amyloid, etc., occur in but one form, either that of a degeneration or that of a deposit as the case may be. Many of the substances which are regarded as deposits are usually found in or near the walls of the smaller blood-vessels, suggesting the posssibility of their formation through changes in the secreting cells of the vessel wall. The new substances are either taken out of the blood by the endothelial cells or are formed by the protoplasm of the latter, and passed out into the lymph spaces of the surrounding tissue after the manner of a secretion. Both amyloid and hyalin appear to be formed in this way.

TRUE DEGENERATIONS.—1. Cloudy swelling. 2. Hydropic degeneration. 3. Fatty degeneration. 4. Colloid degeneration. 5. Mucin. 6. Pseudomucin. 7. Cholesterin. 8. Epithelial hyalin. 9. Cornification. 10. Colloid-like bodies. 11. Pigments formed by cell activity. 12. Glycogen.

DEPOSITS.—1. Fat. 2. Amyloid. 3. Hyalin. 4. Calcification. 5. Uric acid, urates, etc. 6. Cholesterin, cystin, xanthin, etc. 7. Glycogen. 8. Pigment. 9. Extrinsic substances.

TRUE DEGENERATIONS.—*Cloudy Swelling* (Parenchymatous, Granular, or Albuminous Degeneration).—This is the most common form of the true degenerations and is characterized by the splitting up of the cell protoplasm into fluid and albuminous granules. These granules are soluble in acetic acid, insoluble in alkalies and ether, and are not affected by osmic acid. Their presence gives to the cell a cloudy granular appearance: it is swollen and its normal form and structure are lost. In slight degrees of this change the nuclei show but little evidences of disorganization, but in severe cases there are disintegration and loss of staining power of the chromatin. Recovery from the moderate degrees of this degeneration is possible, but after diffusion of the nuclear chromatin the cell undergoes complete destruction, breaking up into a finely granular débris. Cloudy swelling occurs in the cells of the parenchymatous organs, particularly in the liver and kidneys, in the course of the acute infectious diseases, severe intoxications, etc. It is the chief lesion in the kidneys in the acute degenerative nephritis occurring in scarlatina, septicæmia, eclampsia, variola, erysipelas, diphtheria, typhoid fever, etc.; and in such intoxications as mercuric chloride, carbolic acid, phosphorus, arsenic, cantharides, etc. To the naked eye the affected organs appear larger, swollen, less shining than normal, and of a grayish color. In severe cases the organ has the appearance of having been boiled, and possesses a color and consistence similar to that of putty. Fatty degeneration is often associated with cloudy swelling.

Hydropic Degeneration.—In hydropic degeneration there is a partial liquefaction of the protoplasm, leading to the formation of clear vacuoles within the cell. The nucleus may be similarly affected, being indicated by the presence of a large clear globule consisting of the nuclear membrane distended by fluid. This degeneration occurs most frequently as a precursor to liquefaction necrosis, and is found in blisters of the skin, tumor cells, severe œdema, inflammatory processes, etc. It is distinguished from œdema in that the staining power of the nucleus is affected, and from liquefaction necrosis in that in the latter the nucleus is entirely lost.

Fatty Degeneration.—This form of degeneration is characterized by the formation of fat out of the albumin of the cell body. Cells which are in a state of fatty degeneration contain small, colorless, highly refracting droplets which are soluble in alcohol and ether, insoluble in acetic acid, and stain black with osmic acid. These droplets are very irregular in size and shape, but are usually small except in severe cases, in which they may become confluent, forming larger drops. The parenchymatous organs, liver, kidneys, etc., are chiefly affected, but the degeneration occurs also very frequently in heart muscle, voluntary muscle, connective-tissue cells, and leucocytes. Fatty degeneration occurs in a great variety of pathological conditions: acute infectious diseases such as diphtheria, pneumonia, septicæmia, etc.; poisoning by phosphorus, arsenic, chloroform, camphor, etc.; acute anæmia resulting from severe hemorrhage; chronic anæmia and leukæmia; chronic congestion; diminished blood supply caused by sclerosis, thrombosis, etc.; chronic pulmonary tuberculosis, nephritis, chronic alcoholism, etc. The degeneration is dependent partly upon changes in the nutrition of the cell and partly upon a lowered vitality of the cell. The chief factor is a diminished supply of oxygen to the cells, which results in an increased breaking down of the cell albumin, partly into fat and partly into nitrogenous products which are excreted by way of the urine. In the infectious diseases the degeneration must be attributed primarily to the effects of the poisons produced in these diseases, or to the effects of fever. Prolonged high temperatures lead to extensive fatty degeneration, especially of the heart muscle. Cells out of their normal environment, tumor cells, pus cells, etc., also undergo fatty degeneration. Cloudy swelling and hydropic degeneration are very frequently associated with fatty change.

Colloid Degeneration.—Colloid is a more or less firm, hyaline, jelly-like substance, clear or slightly colored, and is produced by the cells of the thyroid follicles. Its chemical nature is unknown; it is probably an albuminous body containing iodothyrin. It is not precipitated by alcohol or acetic acid. When formed in excessive amount the follicles become distended and the gland enlarged (colloid degeneration of thyroid, colloid goitre or bronchocele). This pathological accumulation may occur both in the normal gland and in tumors arising from it. Substances similar to thyroid colloid are found in various conditions of the kidneys, prostate, parotid, etc. Since their chemical nature is not identical, they are classed as *colloid-like bodies.*

Mucin, Pseudomucin.—The pathological formation of a stringy, gelatinous fluid from epithelial cells or connective tissues is known as mucous or myxomatous degeneration. This change has a physiological prototype in the formation of mucus in mucous membranes and glands, and in the umbilical cord, tendons, bursæ, and synovial membranes. In mucous membranes the production of mucus takes place in goblet cells. These are swollen epithelial cells whose protoplasm has become altered into a clear substance containing small granules or strings. In mucous degeneration of epithelium the number of goblet cells becomes greatly increased (catarrhal inflammation). Pus cells, the epithelium of cystadenomata, and carcinoma cells very frequently undergo mucous change. In mesoblastic structures the intercellular substance undergoes a mucous change, becoming altered into a gelatinous mass. The cells of the tissue may also be converted into mucus. This change occurs in fibrous connective tissue, cartilage, bone, bone marrow, and fat, and especially in the case of the mature connective-tissue tumors and the sarcomata. In severe cases the entire tissue may become changed into a clear, translucent mass. The chemical nature of mucus varies greatly in different cases, and at present but little is known of its real composition. Its chief constituents are known as mucin and pseudomucin, and several varieties of these are described, so that it is probable that they do not represent single chemical substances. Mucin is precipitated by acetic acid while pseudomucin is not. From both mucin and pseudomucin a carbohydrate may be formed, from which fact one is justified in classifying them as glyco-proteids. Pseudomucin is found especially in the cystadenomata of the ovary and is the product of the epithelial cells lining the cysts. It is found also in mucous carcinomata.

Cholesterin.—This occurs as a pathological degeneration in tissues and exudates which are in process of fatty degeneration. Its source is not clearly understood, but it is probably an intermediate product in the splitting up of proteids. It occurs in the form of thin, rhombic plates having usually a notched corner, in atheromata, fatty degeneration of sclerotic vessels, old extravasations, and purulent exudates.

Epithelial Hyalin.—Under this head may be grouped all of the substances that arise from the degeneration of epithelial cells and that have a structure like that of the colloid of the thyroid. These substances are, however, very different in origin and chemical nature and cannot be regarded as being identical in kind. It is therefore better to restrict the use of the term hyalin to those degeneration products of epithelial cells which resemble the hyalin of connective tissue in that they stain with fuchsin. Those substances which resemble colloid may then be classed as the colloid-like bodies. As epithelial hyalin may be considered the hyaline granules and globules found especially in cancer cells. These have been held to be parasites, but they are formed as the result of degenerative changes in the cancer cell.

Colloid-like Bodies.—Those pathological substances found in various portions of the body which bear a close resemblance to the colloid of the thyroid, and which like it are the products of epithelial cells, may be classed as colloid-like bodies. The chemical composition of these bodies cannot be identical; their grouping together into one class is based upon general resemblances only. They represent transformed products of epithelium, and in common are hyaline, gelatinous substances which do not stain like mucin. Such bodies occur pathologically in the kidney tubules (casts), ovarian and parovarian cysts, retention cysts in mammary glands, parotid, skin glands, pancreas, kidneys, endometrium, etc. Similar substances are found also in the prostate, hypophysis, central nervous system, lungs, etc. They occur partly in the shape of homogeneous hyaline bodies and partly in the form of laminated concretions. Some of the latter give a reaction resembling that of amyloid (corpora amylacea). Since in the majority of cases these bodies are found in gland spaces, they must be regarded as a modified epithelial product which is formed under conditions very different from those attending the deposit of amyloid, and though occasionally giving a similar reaction cannot be considered as being identical. The colloid-like bodies found in the nervous system are derived either from degenerating neuroglia cells or from fragments of axis cylinders.

Cornification.—Pathological cornification occurs in a great variety of conditions. Hyperplasia of the horny layer of the entire skin may occur (ichthyosis, lichen pilaris, etc.), or local thickening may take place (ichthyotic warts, callosities, corns, etc.). These changes may be included under the general term of hyperkeratosis. Pathological cornification also occurs in regions of the body where normally it does not take place at all or but to a very slight degree. The ducts of the skin glands may be so affected; cornification may also occur in the mucous membrane of the mouth, middle ear, vagina, urinary passages, in the mastoid cells, etc. Further, keratohyalin is formed in tumors of the skin, meninges, brain, etc. In all of these conditions the process is a true cell degeneration, the keratin being formed by the cells at the expense of their nuclei. As the keratohyaline granules are formed and escape from the cells there is at the same time a shrinking of the nuclei, leading ultimately to their disappearance.

Cell Activity.—The pigments which are formed by cell activity—melanin, hæmofuscin, and lipochrome—may all be produced in excessive amounts under certain pathological conditions. This increase of pigment manufacture is analogous to the increased production of mucus, colloid, etc.; and for this reason it may be classed with the true degenerations. An excessive formation of melanin occurs in local melanosis of the skin (pigmented moles, sun-burn, etc.); in general melanosis, in Addison's disease, and in severe cachexias. Melanin degeneration occurs also in the cells of melanotic sarcomata. In these, death of the cell usually follows the formation of the pigment. Hæmofuscin is produced in excessive amount in the atrophy of heart and unstriped muscle. Lipochrome is formed to such an extent in certain forms of sarcoma as to give them a green color (chloroma).

Glycogen.—Glycogen is formed in excess in certain cells and tissues in a number of pathological conditions—in pus cells, in the leucocytes in certain cachexias, and in tumor cells of various kinds. It is not clear whether in these cases the glycogen is derived as such wholly from the blood or is manufactured by the cell from carbohydrates or albumin.

DEPOSITS.—*Fat.*—A pathological deposit of fat may take place in tissues where fat is found normally or in those in which it is not a normal constituent. In excessive accumulation of fat the subcutaneous and subserous adipose tissue, bone marrow, and liver are first affected; later, the intermuscular connective tissue of the heart and voluntary muscles, endocardium, etc., may become the seat of deposit. The fat is deposited in the shape of small droplets which become confluent into larger drops, so that ultimately the entire cell body may be replaced by it and converted into a globular mass of fat. Fatty infiltration occurs in general obesity, congenital and acquired; in chronic anæmia and cachexia; in chronic alcoholism, etc. The causes of pathological accumulations of fat are: excess of nutritive material taken into the body, inability on the part of the body to break down the fat received into it or already stored there, deficient oxygenation of the blood and tissues, chemical substances reducing the metabolic activity of the cells, etc.

Amyloid.—The terms amyloid and lardaceous degeneration have been applied to the deposit of a hyaline, homogeneous, wax-like substance in the walls of the smaller blood-vessels. It may occur in almost every part of the body, but is most commonly found in the spleen, kidneys, and liver; less frequently in the intestine, stomach, lymph glands, pancreas, adrenals; and rarely in the muscles, ovaries, uterus, respiratory tract, etc. As a result of an extensive deposit of amyloid the affected organs become enlarged, translucent, waxy and more resistant. The amyloid substance gives a reaction with iodine somewhat resembling that of starch, and for this reason it was once regarded as a body closely related to cellulose or starch; hence its name amyloid. Later, its nitrogenous nature was discovered, and it is supposed to be a coagulated albuminous body intermediate between the proteids on the one hand and fat and cholesterin on the other. It is very resistant to the action of chemicals and the agents of putrefaction. With certain of the aniline dyes amyloid exhibits a metachromatic reaction. Amyloid is never deposited in living cells, but is found in the interstices of the connective tissue in or near the walls of the smaller blood-vessels. In the early stages of the deposit it lies always just outside of the endothelium. It is therefore probable that it is formed by the secreting cells of the vessel walls and deposited in the lymph spaces in and near the vessels. But little is known concerning its significance and etiology. It occurs most frequently in the various cachexias, especially in pulmonary tuberculosis, chronic suppuration, syphilis, chronic dysentery, leukæmia, etc.

Hyalin.—Closely related to amyloid in its general appearances and mode of formation is the homogeneous deposit found in the walls of blood-vessels and in the interstices of connective tissue which is known as hyalin. It differs from amyloid chiefly in that it does not give the characteristic reactions of the latter. That there exists a very close relationship between the two substances is shown by the fact that amyloid organs often contain hyaline areas which do not give the amyloid reactions, and that pieces of amyloid when introduced into the peritoneal cavity of animals lose their characteristic reactions. In further contradistinction hyalin stains a deep red with Van Gieson's method, while amyloid stains a pinkish-yellow or brown. Hyaline deposit is found chiefly in the walls of blood-vessels (sclerosis), endocardium, connective tissue of the thyroid, lymph glands, ovaries, chronic inflammations of the kidneys, and in the connective tissue of many forms of tumors. In the connective tissue of certain organs, especially in that of the conjunctiva, hyalin appears to be more of the nature of a degeneration than of a deposit. The connective-tissue cells may undergo a change into a hyaline substance containing no nuclei, or the hyaline formation may owe its origin to a secretory activity on the part of the connective-tissue cells. Conjunctival hyalin appears to be formed in this way. In other cases hyalin partakes both of the nature of a degeneration and of that of a deposit, the connective-tissue spaces being first filled with a clear, homogeneous substance into which the cells are gradually fused, the whole ultimately becoming converted into hyalin. The small hyaline granules (fuchsinophile bodies) found in connective tissue are also included by some writers under the head of hyalin. They are partly the results of cell degeneration and partly derived from inflammatory exudates. The deposit of hyalin occurs under conditions similar to those in which amyloid develops: it is found in old age, syphilis, various cachexias, chronic inflammations, etc.

Calcification.—The deposit of lime salts in the body tissues is of very frequent occurrence. Such deposits may consist either of granular and amorphous masses or of crystals. They may occur in the tissues which form a normal part of the structure of the body, or an incrustation may be deposited around tissues which have been separated from their normal surroundings; or foreign substances which have entered the body may become the centre of deposit. In the first case the process is spoken of as calcification of tissue; in the latter as the formation of concretions and calculi. Calcification never takes place in perfectly normal tissue. It is usually preceded by some degenerative change: cloudy swelling, fatty degeneration, hyaline change, necrosis, etc. Dying tissue which has undergone more or less change appears to possess a certain attraction for the lime salts held in solution within the body and to cause their precipitation. Connective tissue which has undergone hyaline change is especially likely to become calcified. Calcification occurs also in areas of caseation in any part of the body, in tissues showing fatty degeneration or beginning necrosis, as in the renal epithelium in cases of poisoning by mercuric chloride, aloin, and bismuth. In old age extensive calcification may occur in tissues which show but little change. This takes place to the greatest extent in cases showing marked osteoporosis. The lime salts removed from the bones are deposited in the capillary walls in the lung, kidneys, and mucosa of the stomach, as well as in the intima of the smaller cerebral vessels. Concretions of lime salts are met with in the meninges, caseating areas, psammomata, nodular growths in connective tissues, organizing thrombi, etc. Calculi composed partly or wholly of lime salts may be found under varying conditions in all of the ducts and cavities of the body (salivary, bronchial, urinary, biliary, prostatic, etc., calculi). All of these possess an organic basis around which the deposit has taken place. The calcium salts found in the body are either the phosphates, the carbonate, or the oxalate. Magnesium salts are not infrequently found in combination with these. Other substances such as uric acid, bile pigment, etc., are also found mixed with lime salts in various forms of calculi.

Uric Acid, Urates.—A deposit of uric-acid salts takes place in gout, chiefly in the form of sodium urate, with which small quantities of calcium phosphate and carbonate are combined. These deposits occur in the kidneys, skin, subcutaneous tissues, tendon sheaths, tendons, ligaments, synovial membranes, and articular cartilages. The great toe is a favorite seat of deposit. In marked cases every organ in the body may be affected. Fine acicular crystals of sodium urate are found in the tissues, which show at the seat of deposit a more or less advanced necrosis. The larger deposits about the joints are called tophi. Uric acid and urates are found in the kidney tubules in the condition known as uric-acid infarct, which is of rather frequent occurrence in the new-born. Calculi of the same substances are found frequently in the tubules and pelvis of the kidney, the ureters, and in the bladder.

Pure uric-acid calculi are small, hard, and reddish in color. Calculi of urates are usually partly composed of lime salts.

Cholesterin, Cystin, etc.—Cholesterin is found as a deposit in gall stones. These may consist of pure cholesterin or be combined with bile pigment, lime salts, etc. Cystin calculi are found in rare conditions when cystin is excreted by the kidneys as the result of peculiar metamorphoses of albumin produced in the intestine through the action of bacteria. Cystin calculi are yellowish, soft, and waxy. Calculi composed of xanthin are found rarely in the bladder. They are red in color, and of a soft, friable consistence.

Glycogen.—In diabetes excessive amounts of glycogen are conveyed by the blood to certain organs where it is deposited in the parenchymatous cells. This takes place to the most marked extent in the kidneys where the glycogen is deposited in the epithelium of Henle's loops, especially in the isthmus of these where the cells are almost entirely filled with it. It appears in the cells in the form of hyaline droplets which are usually collected near the nuclei. After the glycogen has been dissolved out by water clear vacuoles are left in the cell.

Pigment.—Melanin may occur as a deposit in various organs, especially in the spleen, lymph glands, and kidney, in the case of necrosing melanotic sarcomata in which the pigment is either set free in the blood or lymph or carried there by leucocytes. It may also appear in the urine, and casts of melanin may be found in the renal tubules. In icterus the bile pigment may be deposited in all of the tissues and organs of the body, giving to them a yellow or greenish color. Hæmatogenous pigments, hæmatoidin and hæmosiderin, are found in the tissues as remains of hemorrhages. The pigment granules may be taken up by leucocytes and carried to the spleen, lymph glands, bone marrow, etc., being deposited in these organs in the shape of yellow or brown granules which may be so numerous as to impart a distinct color to the part. In many of the acute infectious diseases, malaria, pernicious anæmia, leukæmia, various forms of poisoning, etc., large numbers of red blood corpuscles may be broken down and an increased amount of blood pigment be carried to the spleen, liver, kidneys, etc. This may be compensated for by an increased activity on the part of the liver in the formation of bile, but if the amount of hæmoglobin is too great to be disposed of in this way pigment may be deposited in the liver cells and in other organs and tissues. Such organs become yellow or brown if the deposit is at all marked, and to this condition the term hæmochromatosis has been applied. Since hæmosiderin is the pigment most commonly found it is proper to speak of the pigmentation as a hæmosiderosis. In the liver cells hæmatoidin is usually deposited in the central zone of the lobule, while hæmosiderin is found in the periphery of the lobule. In the kidneys the pigment is deposited chiefly in the cells of the convoluted tubules; in the spleen, lymph glands, and bone marrow it is contained chiefly within the endothelial cells lining the blood spaces. Through the absorption of hydrogen sulphide from the intestine, organs containing hæmosiderin in excess may become black in color (pseudo-melanosis). In addition to the hæmotogenous pigments formed in malaria through the destruction of the red blood cells, the pigment formed by the plasmodia themselves may collect in the smaller arterioles and capillaries. It is black, contains no iron, and its exact chemical nature is unknown.

Extrinsic Substances.—Foreign substances may be introduced into the body from without and be deposited in the tissues. The variety of such substances is very great and their mode of entrance into the body is also greatly varied. Insoluble substances may be introduced through open wounds of the skin (tattooing, trauma). The lungs are the most frequent point of entrance: through them coal dust, stone and iron dust, soot, etc., enter and are deposited in the lung tissues and in the bronchial lymph glands. Under certain conditions (tuberculous caseation, etc.) these substances may get into the general circulation and be deposited in the liver, spleen, bone marrow, etc. Soluble metallic salts, such as those of silver and lead, may be taken in through the stomach and intestine, and deposited in certain organs and tissues in an insoluble form.

The causes leading to the pathological degenerations and deposits may be either intrinsic or extrinsic. The former may be inherited or it may arise by primary germ variation. For the greater part both degenerations and deposits are produced by injurious extrinsic influences to which the body is exposed during life. Disturbances of nutrition, deficient oxygenation, circulatory disturbances, intoxications, infections, etc., play the chief part in their production, but any external force which may injure the body may lead likewise to pathological alterations of its organs or tissues which may assume either the form of a degeneration or that of a deposit. These changes may be of limited extent or the entire organism may suffer as the result of general disturbances of nutrition. Deposits may be followed by secondary retrograde changes, such as atrophy, fatty degeneration, etc., as the result of pressure or diminished blood supply. No general statements can be made regarding the course and symptomatology of the degenerations and deposits, as these vary within the widest limits according to their etiology and association with other pathological conditions. (See also *Amyloid, Colloid, Concretions,* etc.)

Aldred Scott Warthin.

DEGLUTITION.—Deglutition is the physiological act or process by which food is conveyed to the stomach. There are two principal theories in regard to its mechanism, one based upon the description of Magendie, the other upon the investigations of Kronecker and Meltzer.

Following Magendie, it is customary to describe the act of swallowing as occurring in three stages, each representing the passage of the food through one of the three anatomical regions involved, namely, the mouth, the pharynx, and the œsophagus. After the food has been masticated and collected into a bolus, the mouth is closed and the jaws are brought together. Deglutition then begins with the elevation of the tongue against the palate, its tip, middle, and base pressing upward in succession, through the action of its intrinsic muscles and the stylo-glossus. The bolus is thus forced backward through the isthmus of the fauces into the pharynx. During its passage the soft palate is elevated by the contraction of the levator palati muscles and is made tense by the tensor palati; the pillars are made straight and tense through the action of the palato-pharyngeus, which also assists in the closure of the posterior nares. There is at the same time a slight protrusion forward of the posterior wall of the pharynx through the contraction of the salpingo-pharyngeus, and the uvula is elevated by the azygos-uvulæ to complete the closure of the passage into the posterior nares.

This, the first stage, is regarded as voluntary in character; but it is not fully under control of the will, for in the absence of a moist bolus or of fluid to be swallowed the act becomes difficult and cannot be repeated indefinitely; the presence of dry food or of a dry powder on the tongue exerts an inhibitory influence.

The second stage consists in the passage of the food through the pharynx, which is accomplished by a number of rapid muscular movements. The contraction of the stylo-pharyngeus and palato-pharyngeus muscles raises the pharynx like a funnel and tends to draw it over the descending bolus, which is now seized and carried rapidly downward by the constrictors of the pharynx. The approximation of the anterior pillars of the fauces through the action of the palato-glossi prevents its regurgitation. The other muscular movements which accompany these have for their object the closure of the glottis. This is accomplished by the elevation of the thyroid cartilages behind the hyoid bone through the action of the laryngeal muscles; the approximation of the arytenoid cartilages and the vocal cords by the lateral crico-arytenoids and the constrictors of the glottis; and the depression of the epiglottis, which is sometimes accomplished, perhaps, in a purely mechanical way, but is normally brought about by the concerted action of the thyro-hyoids, digastrics, genio-hyoids, mylo-hyoids, and the fibres in the aryteno-epiglottic folds.

The third stage is a much slower movement, requiring six seconds for its completion. The food enters the œsophagus with great rapidity and continues to move rapidly through its upper third, the part supplied with striated muscle fibres. Through the lower two-thirds the movement is slower, depending solely upon the involuntary musculature.

The Kronecker-Meltzer theory attributes the most important part in deglutition to the contraction of the mylo-hyoid muscle and is based upon carefully conducted experiments. After the bolus of food has been collected on the dorsum of the tongue and its passage forward has been prevented by the elevation of the tip against the palate, these muscles contract with force and put so great pressure upon the bolus that it is shot through the pharynx into the œsophagus, the action being assisted by the simultaneous contraction of the hypoglossi which draw the tongue backward and downward and thus increase the pressure. This action also serves to depress the epiglottis and to protect the larynx. Soft or liquid food passes rapidly through the œsophagus to the cardiac orifice of the stomach, the time required for its descent being not more than one-tenth of a second. The peristaltic wave of the œsophagus is regarded as a reserve movement intended for the removal of such fragments as lodge in descent or for the completion of deglutition when the bolus is not of a proper character for rapid descent. It is needed, however, in many individuals to force the food through the cardiac constriction. Six seconds are required for the completion of the act in this manner. The œsophagus contracts in three successive segments. The first is about 6 cm. long and is the neck portion, the part endowed with striated muscle. It begins to contract in about one or one and two-tenths seconds after the beginning of deglutition and requires two seconds for its completion. The second segment, the upper thoracic portion, is about 10 cm. in length; its contraction begins about one and eight-tenths seconds after the first segment begins to contract and lasts for from six to seven seconds. The remaining third portion begins to contract about three seconds later than the second and continues for from nine to ten seconds. The act of deglutition is thus divided into five instead of three stages, corresponding to the contraction of the mylo-hyoids, the constrictors of the pharynx, and the three œsophageal segments. A single act of swallowing requires six seconds for its completion, as stated; but if the act be repeated within this time, it was observed that the peristaltic wave is arrested and that the bolus is carried to the stomach by a subsequent wave which is completed six seconds after the beginning of the last deglutition.

Nervous Control.—Deglutition is a reflex act. A certain stimulus, as that of food or drink or a few drops of saliva, seems to be required for the perfect accomplishment of even the first stage, the most voluntary part of it. The afferent impulse is conveyed, presumably from the mucous membrane of the mouth or pharynx, to the deglutition centre by the glosso-pharyngeal, trifacial, and pneumogastric through the internal branch of its superior laryngeal division. No deglutition centre has been definitely located, but it is supposed to lie near the anterior surface of the medulla. It probably comprises parts of the nuclei of origin of the nerves employed in the act of swallowing, namely, the hypoglossal, facial, trifacial, glosso-pharyngeal, and pneumogastric, and is not an individual collection of cells.

Mosso found that when an entire segment of the œsophagus is removed the contraction of the part below the injury takes place in its natural order as though the tube were intact. Kronecker and Meltzer observed the same action after ligature or division. This is made possible by the manner in which the tube is innervated by branches of the pneumogastric and sympathetic. These form a plexus between the muscular coats in which are groups of ganglion cells and another in the submucous layer. Although the part taken by each of these cannot be exactly described, the impulses are conveyed through them in such a manner that the wave of contraction travels downward from the upper portions to the lower regardless of the integrity of the tube. *James M. French.*

DELIRIUM.—The term *delirium* does not indicate any special disease, but a psychopathic condition, which may be observed during the course of a great many mental diseases. This condition is characterized by an incoherence in the chain of conceptions, and by the appearance of symptoms of psycho-sensory and psycho-motor irritation. The incoherence of conceptions is evident in the disconnected and confused speech and in the aimless movements of the patient. Hallucinations are produced by the psycho-sensory irritation, and the psycho-motor irritation is responsible for the impulsive movements sometimes manifested in a very high degree.

As is well known, delirium appears most frequently in the course of the acute infectious diseases. One must, however, bear in mind that not every psychical disturbance during these diseases must necessarily be a delirium. Isolated delusions, maniacal excitation, and acute hallucinations appear here just as frequently as delirium, and it is well to distinguish sharply between these conditions as they may each have a different significance. A genuine delirium indicates often a state of inanition and demands energetic stimulation.

Delirium may appear in the course of various mental diseases, and in such instances always indicates general exhaustion. It is of bad prognostic significance when it develops gradually under these circumstances, and is not infrequently the first sign of approaching death. There seems to be a special tendency toward the development of delirium in the course of functional psychoses which are complicated by some organic disease, such as a valvular lesion of the heart, a chronic nephritis, etc. Frequently delirium arises in organic diseases of the brain as a sequel to some acute lesion of the brain substance, such as minute hemorrhages, emboli, or œdema.

When a delirium suddenly develops without warning in a previously healthy person, a correct judgment of the case becomes much more difficult than when it appears in the course of certain diseases. These are the cases which the general practitioner sees in relative frequency. A person, who has heretofore been perfectly well, suddenly becomes confused in speech, runs aimlessly about his room, and appears to recognize no one about him. The nearest physician is sent for and recognizes an acute delirium. The question then is: What is the nosological significance of such an acute delirium? Is it an independent disease, which has suddenly developed, or is it but a complex of symptoms, which may be evoked by different diseases, and, if so, what means have we at our disposal to clear up the pathological condition?

The relative frequency of acute delirium gave rise to the idea that these attacks were due to a special form of disease, which was described under the name of "delirium acutum." This view, however, has been proved to be erroneous. An acute delirium does not constitute a *morbus sui generis*, but represents only a transitory condition of the most varied mental disorders. Let us, therefore, consider the various diseases which may be responsible for an attack of acute delirium and attempt, at the same time, to bring out the different points which may lead us to a correct diagnosis in every individual case.

The previous history of the patient may be of great value in our conclusions concerning an acute delirium. A history of previous epileptic attacks, for example, may put us upon the right track of the etiology. The psychic epileptic state is, as is well known, mainly characterized by a disturbance of consciousness, and even though this disturbance does not, as a rule, produce a delirious condition, still it is not so very rare for the clinical picture of a delirium to appear during the life of an epileptic individual. The relation of a delirium to a true epileptic seizure may be varied in particulars. The delirium may either follow or precede the attack. In some instances the epileptic convulsions may be wholly absent and the delirium may take their place as any other psychical equivalent of a genuine seizure. Delirium may sometimes be the only symptom in those cases which are known as larvated or psychic epilepsy. The diagnosis must be made in these instances by the periodicity of the seizures, by the sudden disturbance of consciousness, by aura-like appearances, by the stuporous condition following the attack, by hereditary taint, as well as by certain neurotic symptoms, showing themselves in the intervals, and by the well-known epileptic character of the individual.

The history of a recent acute infectious disease may lead to the correct judgment of an acute delirium. It is a well-known fact that the acute febrile diseases play an important factor in the etiology of mental disturbances. The clinical form of the psychoses belonging to this group is very variable, and, in fact, the changeability of the various psychopathic states is characteristic for these diseases. The patient may rapidly pass from a melancholic to a maniacal condition, and soon manifest all sorts of psychopathic symptoms. The mental disturbances in cases of this kind are frequently interrupted by lucid intervals, or by intermissions, lasting for several days. The beginning of the psychic disturbance in this group may not manifest itself for weeks or months after the termination of the infectious disease. Occasionally the psychosis may start with an acute delirium.

In general, the prognosis of this group of psychoses is favorable. Those cases, however, in which delirium constantly predominates usually represent a state of inanition, which occasionally may prove fatal, particularly in weak persons. This form, on the other hand, is not nearly so apt to run into a secondary chronic psychosis as another type, in which a regular set of delusions is developed soon after the outburst of the delirium, as, for instance, in acute hallucinatory paranoia.

Besides the acute infectious diseases, such as typhoid fever, malaria, influenza, pneumonia, pleurisy, multiple neuritis, articular rheumatism, erysipelas, scarlatina, etc., acute poisoning may produce psychoses which belong to the class under discussion. Delirium has been observed after large doses of salicylic acid, cannabis indica, belladonna, conium, ergot, etc. It has also been seen after the use of iodoform in and about wounds, and sometimes after a lengthy administration of ether or chloroform. The inhalation of poisonous gases, such as carbonic oxide, hydrogen sulphide, carbon disulphide, nitrogen monoxide, etc., may have as a sequel psychic disturbances of the kind described.

Psychopathic phenomena beginning with delirium may develop from chronic toxic conditions produced by the abuse of chloral and chloroform, or by the habitual use of opium, morphine, cocaine, absinthe, and, above all, alcohol. The predominance of delirium over all other psychic symptoms is responsible for the origin of the well-known term *delirium tremens*, so frequently seen in chronic alcoholism. Here, too, delirium is seen only in connection with other existing conditions. The delirium itself may sometimes be only of minor importance and, indeed, may be totally absent, being then replaced by such phenomena as hallucinatory confusion or maniacal exaltation. An acute delirium in the course of chronic poisoning may arise without direct cause, it may immediately follow excesses, or it may appear as a sequel of abstinence.

Chronic forms of metallic poisoning are sometimes characterized by similar psychic derangements. The principal features of saturnine encephalopathy are of an acute delirious nature. Cases of so-called "transitory lead mania" have been observed frequently. Mercurial psychoses, too, are mainly characterized by delirious conditions. Further, it is proper to place in this category those cases of lyssa the psychical disturbances of which, as a rule, take the form of an acute delirium. A comparatively large percentage of acute delirium is formed by the puerperal psychoses. Acute delirium, following even minor operations, has been frequently described. Traumatic injuries, especially those affecting the skull, may also evoke delirium.

Those cases which have been described under the name of *acute general paresis* begin, as a rule, with an acute delirium, and end fatally within a few days or weeks. These instances form a large proportion of the cases described as *delirium acutum.* If one examines carefully the previous history of such patients, it will almost always appear that, although the patient was in seeming good health, a series of derangements will be found which are characteristic of *general paresis.* The relatives will state that the patient had shown changes in character for some time past, that he had become indifferent to things which had previously interested him, that he frequently forgot important things, that his dealings appeared to be queer and without motive, etc. The autopsy in such cases shows pathological changes of some duration, whose influence had remained latent, such as a chronic interstitial encephalitis, atrophy and softening in isolated cortical areas, thickening of the dura, etc.

Despite the most careful research, it may prove impossible, in a certain number of cases of acute delirium, to draw any conclusions regarding the pathogenesis from the history of the patient. In this event, we may have to deal with a sudden attack in a previously perfectly healthy individual. Here a thorough examination of the internal organs may give some clew as to the origin of the disease.

I have already alluded to a twofold relation between delirium and the acute infectious diseases. I have mentioned the delirium arising during a febrile disease and that accompanying a psychosis which is the result of such an ailment. I shall now consider a third group, which shows a relation between the two conditions. A person, previously in perfect health, may suddenly be thrown into a state of agitation and confusion. An acute psychosis is diagnosticated, and the patient may be transferred to an institution. After a while it appears that he is suffering from typhoid fever or some other infectious disease. Acute delirium of this nature without any prodromes occurs especially in erysipelas and acute articular rheumatism, in typhoid fever, and in meningitis. But even minor infectious diseases, such, for example, as a follicular tonsillitis, have given rise to similar phenomena.

The diagnostic and therapeutic importance of a careful physical examination in these cases is self-evident. A number of cases, no doubt, starting with elevated temperature, and diagnosticated as so-called *delirium acutum,* may belong in this category. The diagnosis of meningitis usually offers no great difficulty on account of the typical symptoms on the part of the cranial nerves. In typhoid fever, the enlarged spleen, the quality of the dejections, and the presence of a roseola will lead to the correct diagnosis, although all these symptoms may sometimes remain absent for a considerable time. The correct somatic diagnosis of acute rheumatism is, as a rule, not difficult.

The examination of the urine in a case of delirium of acute origin must never be neglected. Although it is a well-known fact that in the course of psychoses, and specially during delirium, albumin and hyaline casts may be found in the urine with no post-mortem changes in the kidneys, yet it is not rare for an acute delirium to start a psychosis which is dependent upon a chronic, possibly latent nephritis. Occasionally the cerebral features of a uræmia may present the clinical picture of acute delirium, although, as a rule, they are characterized by epileptiform seizures or comatose conditions.

The cerebral symptoms of some other forms of disturbed metabolic processes may assume the form of delirium. Now and then an acute delirium may take the place of the familiar diabetic coma, and it may, in fact, be the first symptom of an overlooked diabetes.

So then I may conclude by saying that *delirium* constitutes an independent psychopathic condition, which, however, does not form a *morbus sui generis,* but occurs during the course of a great many mental diseases. A correct conception of the pathological nature of this condition is of the greatest importance in diagnostic, prognostic, and therapeutic respects. *William Hirsch.*

DELPHINIUM. See *Larkspur*, under *Poisonous Plants.*

DELUSIONS. See *Insanity*, and *Paranoia.*

DEMULCENTS (from Latin *demulcere*—to soothe) are bland substances of a mucilaginous or oleaginous character, which exert a soothing, softening, or protecting influence on the parts to which they are applied. In the past the terms demulcent and emollient have been used somewhat vaguely, and to a large extent interchangeably; but in the present instance demulcent is limited to substances applied internally, to mucous membranes; in opposition to emollients, which are applied to the skin (see article *Emollients*). The chief action of demulcents is mechanical and physical; inflamed surfaces are protected from substances which in passing over them would irritate them; and a protective coating is afforded to any mucous surface which requires lubrication when the natural secretion fails. Thus the respiratory, gastro-intestinal, and genito-urinary tracts are chiefly amenable to the action of demulcents. The medicinal action, if any, is very slight. The chief demulcent is water; and the various substances which are dissolved in it act mainly as so many means of increasing the adhesiveness of the water. Demulcents allay inflammation, relieve irritation, and quench thirst; and in the genito-urinary tract by diluting the urine they diminish its concentration, lessen its acidity, and thus protect the mucous membrane of the bladder and urethra. In the digestive tract, substances like bread and potatoes, if swallowed after the ingestion of pointed articles, afford protection by producing a soft mass in which the foreign substances can become embedded, and in the indigestible residue of which they can travel through the intestines without causing injury, and possibly with little or no inconvenience.

Next to water, the principal demulcents are: Acacia, almond, almond oil, althea, barley, bread, cassia, cetraria, chondrus, elm, flaxseed, figs, glycyrrhiza, honey, ice, isinglass, lichen, linseed, milk, olive oil, sassafras, syrup, tamarind, tragacanth, wheat, white of egg.

R. J. E. Scott.

DENGUE FEVER.—Definition.—The name dengue has been given to an acute, febrile, eruptive disease which generally occurs as an epidemic in hot climates—though occasionally sporadic cases are seen. Dengue is ordinarily abrupt in development, but may occur after several days of prodromal symptoms. The initial symptoms are severe frontal headache, pain in the eyeballs, intense pain with swelling of the muscles and joints—the pains wandering from part to part of the body. A cutaneous eruption occurs on or about the third day in the majority of cases of dengue; it commences on the palms of the hands, and rapidly extends over the entire body. As a rule, dengue is a disease of one febrile paroxysm—with or without remissions; though in severe cases two or more paroxysms of fever, with distinct intermissions, have repeatedly been observed, and verified by the thermometer, the intermissions being of variable duration.

Synonyms.—This disease has, from its first appearance, been known by different names, which have varied according to the views held by different writers, who often have associated it with an idea of the prominent symptom, or with some fancied agency of causation, or with some indefinite idea of pathology; while with other writers the name was associated with some locality in which the disease frequently prevailed, or from which it was imported. Hence we find dengue called as follows: "African fever," so called from the fact that it first appeared after the arrival of a cargo of slaves from Africa; "dandy fever," a name given to it by the English negroes on the island of St. Thomas, in consequence of the affected, stiff gait of those seized by the disease. In Cuba the word dandy was, upon the appearance of this fever there, corrupted in Spanish, and pronounced Dunga or Dengue. It is also called: Scarlatina rheumatica, Cock; break-bone fever; stiff-necked fever; broken-wing fever; eruptive epidemic fever of India; neuralgic fever; eruptive articular fever; eruptive rheumatic fever; giraffe, so called from the symptom of stiff neck; Aden fever, so named because it was thought to have been imported from Aden, Arabia; sun fever; date fever, etc.

History.—The hisory of dengue can be traced only to the latter part of the eighteenth century. This disease has occurred sporadically, or epidemically, in India, Burmah, Persia, Egypt, West Indies, and in North and South America. It has never prevailed in England. Epidemics of dengue prevailing over vast tracts of country have from time to time been observed, and the history of each epidemic recorded. In America all writings on this subject prior to those of Dr. Samuel Henry Dickson, then of Charleston, S. C., afterward of Philadelphia, were unreliable. Dr. Dickson's first publication on dengue appeared in Bell's "Medical Library," 1839; the paper was founded on his experience in the epidemic of 1828, in Charleston, S. C. From this first publication of Dr. Dickson his name has been inseparably connected with the subject of dengue, and he is to this day authority on the subject. The first notice of dengue in America is from the pen of Dr. Rush, giving a history of the epidemic in Philadelphia, which prevailed in the summer and fall of 1780. This author, writing of "Bilious Remittent Fever," says: "The disease was commonly called break-bone fever, in consequence of the violence of its attendant pains."

According to Zuelzer, our first knowledge of this affection dates from the year 1779. Dr. Brylon, at the time one of the most distinguished physicians of Java, writes of an epidemic disease, called knockelkoorts ("bone fever"), which attacked the Batavians. In addition to Dr. Rush's history of the epidemic of 1780, in Philadelphia, Wise recorded his observations of epidemics in Coromandel, Arabia, Persia, Africa, and Thibet. Aitken informs us that dengue prevailed in Calcutta in 1824, and the epidemic was so generally prevalent that but few persons out of a population of five hundred thousand escaped the disease. In 1827–28 it prevailed as an epidemic on the islands of Santa Cruz and St. Thomas to such an extent that but few individuals out of a population of twelve thousand escaped infection.

Hirsch says: "The epidemic of dengue in 1827 first showed itself in September upon the island of St. Thomas, and the next month in St. Croix; it went thence in one direction over the Antilles toward the mainland of North America, in the other over the Caribbean Islands toward Colombia, and lasted until September, 1828, at which time it had reached Savannah, Ga., and sporadic cases were found in many of the larger cities of the United States, notably in Boston, Mass., and New York."

In 1850 an epidemic of dengue prevailed in the Southern States, and attacked the inhabitants of Charleston, S. C.; Savannah and Augusta, Ga.; Mobile, Ala.; New Orleans and New Iberia, La.; and extended into the State of Texas. This epidemic was noted for its general prevalence in the above-named cities. In Charleston, Dr. Wragg says, eight-tenths of the inhabitants had dengue within a period of six weeks. Dr. Henry F. Campbell, of Augusta, Ga., who witnessed the epidemic of 1850, and has written an interesting history of it, says that fully eight thousand out of a total population of eleven thousand were infected.

In 1873 an epidemic of dengue prevailed in the Gulf States, and, like that of 1850, was noted for its general prevalence. In New Orleans, forty thousand inhabitants contracted the disease within a few weeks.

The most recent, and probably the most widespread, epidemic of dengue in America was that of 1880. Among other places visited during that epidemic were Charleston, Beaufort, Port Royal, Columbia, Summerville, Aiken, Branchville, Midway, Blackville, Bamberg, and Georgetown, in South Carolina; Wilmington, N. C.; Augusta and Savannah in Georgia; Key West, Fla.; Biloxi, Miss.; Bay St. Louis, Mo.; New Orleans and Vidalia in Louisiana; and Navasota, Tex. This disease also prevailed in Egypt in 1880 as an epidemic. On October 14th, 1880, Dr. Neroustsos Bey, President of the General Board of Health of Egypt, reported an epidemic of dengue, which began at Cairo and soon spread over the whole of Egypt. In Cairo more than fifty per cent. of the entire population had the disease—the mortality was reported as small.

However interesting it might be further to trace the rise and progress of epidemics of dengue, and attempt to track the infection from place to place, no such effort will be made, as the limits of this paper will not permit it. It is proper to add that it has been found impossible to state definitely the source of the epidemic of dengue in this country in 1880.

ETIOLOGY AND PROPAGATION.—It is impossible to state definitely the origin of dengue fever. That it is an infectious disease, there can be no question. That the poison or germs of this disease possess the quality of portability, there can also be no question, for I might cite innumerable instances in which infected articles of wearing apparel, bedding, or air confined in trunks, cars, or vessels, had served as the media for scattering dengue from an infected into a healthy locality. At the present time it is impossible to determine whether or not it is contagious, in the ordinary meaning of the term. Such competent observers as Samuel Henry Dickson and M. Sheriff adhere to the doctrine of contagion. Others of equal opportunity for accurate observation, and of equal professional reputation, deny that it is a contagious disease. The majority of physicians who have encountered epidemics of dengue are undecided as to whether or not it be contagious. Dickson, one of the highest authorities on this disease, says: "But no pestilence whatever, neither smallpox, nor plague, nor yellow fever, nor cholera, assails so large a proportion of any population as dengue has done on the two occasions of its prevalence." He is decided in opinion that it is a contagious affection, and cites the following history of his own household: In the epidemic of 1828 all of the members of his family, himself included, were attacked. Of his household in 1850, himself and his cook, who alone escaped, were the only ones who remained of those who composed his family in 1828, his children being away and his kitchen filled with new occupants. In 1828 his household numbered 12; in 1850, 30. Dickson supposed that the profession admitted the contagiousness of dengue. This view has been combated by various writers, among whom is Dr. W. T. Wragg, of Charleston, S. C., himself an historian of the epidemic of 1850. Dr. Wragg cites the following considerations which induced him to believe the disease to be non-contagious: 1. Its rapid and almost simultaneous diffusion, precluding the idea of personal communication. 2. The very limited extent to which it prevailed in the vicinity of Charleston, and the absence of evidences of its having been transported into the interior, although the city was thronged with persons from all parts of the neighboring country on business. 3. The incredibly short period of incubation, on the supposition of a contagious miasm having been imbibed. To these considerations another important one should have been added, *i.e.*, the short and uniform career of the epidemics in places where the disease prevailed, and their entire and speedy disappearance. It should also be remembered that dengue is dependent more or less upon climate, seasons, and atmospheric conditions. All of these considerations militate against the idea of dissemination by contagion.

To show the portability of the poison or germs of dengue, and the rapidity of dissemination under favorable conditions, the following is quoted from Zuelzer:

"As a result of the constant communication with ports in the southern seas, the disease was carried in 1871 to Zanzibar and other ports on the African coast. . . . Furthermore, it was imported directly into Bombay and Cananore by two troop-ships (M. Sheriff). Thence the epidemic extended, in 1872, through all India, though confined at first to the Madras and Bombay Presidencies, especially along the railroads. Even in other English stations in Burmah, China, and Nepaul, cases of this highly remarkable epidemic were found. In its diffusion the disease was as widespread as it was intense. In some of the cities attacked scarcely an inhabitant remained exempt. It prevailed most violently and most extensively in Madras, where not a house escaped, and it attacked equally both sexes and all ages (the oldest patient was eighty years, the youngest two months old), and persons of every condition, even up to the highest classes."

SYMPTOMS.—Dengue is generally sudden in its invasion, the patient having been in usual health up to the time of the initial symptoms. The period of incubation varies from forty-eight hours to five days. In the majority of cases the initial symptoms are cephalalgia, photophobia, lassitude, anorexia, nausea, chilliness with occasional flushes of heat, aching or intense pain in the limbs, joints, or muscles. The fever ranges from 101° to 107° F., and is usually coincident with the affection of the muscles and joints. The pulse is rapid, full, and bounding, varying from 95 to 140 beats per minute. The face is flushed, and the eyes are red, wild, and watery. These symptoms persist for from a few hours to several days, when, in the majority of cases, an eruption appears on the surface of the body. The eruption is not uniform in character—a large portion of the various types being represented. While in a number of cases it has the appearance of a simple erythema, in others it more nearly resembles that of scarlatina, rubeola, lichen, urticaria, etc.

In the vast majority of cases of dengue attended by me in the epidemic in Augusta in 1880—more than five hundred in all—there seemed to be but one febrile paroxysm, which ordinarily lasted for from four to seven days. Remissions in temperature were commonly observed, but intermissions of fever were very rare. After cessation of the fever the temperature in several cases descended to 97.5° F. My observations with the thermometer in dengue confirmed the statement of D'Aquin, of New Orleans, that there was a continuous and steady rise in temperature until the highest point was reached on the first, second, or third day of the attack (most generally in my experience on the second day); then a short stadium of a few hours; then a remission, soon to be followed by another rise in temperature, but never reaching the point of first maximum heat. With the rise of temperature a corresponding rise of pulse will be observed, and a decrease in frequency of pulse with a decline of fever. At the height of the fever the respiration is increased in frequency—usually preserving the ratio to frequency of pulse and height of temperature. During the height of the fever the skin is dry and "burning hot." The bowels in the early course of the disease are constipated, but diarrhœa is the rule after the crisis is reached. The urine is generally high-colored, free from albumin, and never suppressed.

There is always a marked tendency to the occurrence of hemorrhages, the hemorrhage being from the nose, gums, bowels, stomach, or lungs, and in females from the womb. In pregnant women there is imminent danger of abortion or miscarriage. I have seen two cases of black vomit similar in appearance to that of yellow fever; I have seen three cases of alarming hemorrhages from the bowels—one of these persisted for several months, and finally caused the death of the patient. Nasal hemorrhages are frequent, and occasionally it is impossible to stanch the flow of blood until an instrument is introduced and the nose plugged. In fully seventy-five per cent. of the cases of dengue in my practice an eruption was seen by me or by some person in attendance. The time of its appearance, as well as the kind, varied with individual cases. It was ordinarily attended with great heat and itching. The palms of the hands, the face, neck, and chest were usually invaded in the order here given. Wherever it began it soon spread over the whole body. In many cases it was extremely light and transient—lasting only a few hours; in others it was severe, and persisted for several days. Desquamation is frequently seen. The eruption usually appears as the fever begins to decrease, which is ordinarily on the third day. With its appearance the lymphatic glands of the neck, axillæ, and groins become enlarged. These enlargements of the glands, and the soreness of the muscles and joints, oftentimes persist for weeks and months after the eruption and fever have disappeared. In many cases the prostration continues for months, and totally disqualifies the subject for mental or physical exertion. I have known both physical and mental prostration to persist for six months after all symptoms of dengue had vanished. It may be truthfully affirmed that wellnigh invariably the convalescence is slow and wearisome, and altogether out of proportion to what is witnessed in any other disease so non-fatal in its issue. During the entire course of dengue insomnia is frequently encountered. It is persistent and intolerable, and whatever sleep is obtained is unrefreshing, and the patients long for more. But that which particularly characterizes the whole course of dengue, and which gives to the patient an experience never to be forgotten, is the pain. It is disproportionate to all other symptoms. It is intense, insufferable, persistent; by day and by night the patient is tortured and harassed by agonizing pains in every portion of the body—pain in the head, limbs, back, joints, muscles, and apparently in the very substance of the bones; pains which are stabbing, boring; at one time fixed, at another fugitive; hard to bear when the body is quiet, intolerable when a limb is gently moved; pain which no attitude of the body can assuage and no medicine of the physician wholly subdue causes the subject of dengue to declare that this is the sum total of human misery. From personal experience I testify to the truthfulness of the assertion.

Relapses are occasionally observed—sometimes after an interval of two or three weeks from the original attack. As a rule the relapse runs a milder course than the primary attack.

Pathological Anatomy.—Dengue being proverbially a non-fatal disease the pathological processes occurring during its course are wholly unknown.

Prognosis.—The prognosis is almost invariably favorable. Death from dengue is extremely rare, save when it attacks very young or feeble children, or very old and debilitated individuals. When death is observed during the course of dengue the fatal result is almost invariably due to some complication, such as convulsions, diarrhœa, hemorrhage, or abortion, or it is the result of some intercurrent disease.

Differential Diagnosis.—From 1828, when Dr. Osgood wrote a description of dengue as seen by him in the epidemic in Havana, till the present day, the idea that it and yellow fever were identical, or, at least, that dengue was modified yellow fever, has continued to find advocates among a goodly number of reputable physicians who have studied these diseases at the bedside. While they have some features and characteristics which are common to both, there can be no question that in most important particulars they are essentially and radically different, and that each disease is *sui generis*, having its own specific poison, and producing its own kind. The following is a brief summary of the points of similarity and dissimilarity in dengue and yellow fever:

In time of appearance, and generally in geographical distribution (but not in pathological lesions, so far as known), they seem related to one another. Dengue, however, has prevailed in Asia, Egypt, and India, where yellow fever is unknown. Both disorders are arrested by severe frost. Both dengue and yellow fever are diseases characterized by one febrile paroxysm. In dengue, however, the fever rises regularly until the acme is reached, when a short stadium of a few hours occurs, followed by remission, when a second rise of temperature takes place, but never reaches the height observed prior to remission. In yellow fever the temperature rises steadily. In dengue the pulse increases in frequency with the rise of temperature; in yellow fever the pulse becomes slower while the temperature rises. Duration of the fever in dengue is from five to eight days; in yellow fever it lasts seventy-two hours. In dengue vomiting is rare; in yellow fever vomiting is frequent. Dengue is characterized by an eruption in the vast majority of cases; in yellow fever an eruption is extremely rare. In dengue jaundice is extremely rare; in yellow fever jaundice is almost invariably present. In dengue the urine is generally high-colored, normal in quantity, free from albumin, and never suppressed; in yellow fever the urine is scanty, albuminous, and often suppressed. In dengue there is a decided tendency to hemorrhages from nose, gum, bowels, lungs, and womb, with occasionally black vomit, but these hemorrhages are, as a rule, insignificant; while in yellow fever they are frequent, alarming, and often fatal. Dengue is proverbially a non-fatal disease; yellow fever is very fatal. Dengue is not protective against yellow fever, nor yellow fever against dengue. One attack of dengue is not protective against a second; one attack of yellow fever is usually protective against another. Finally, dengue runs a more protracted course, and is followed by a more prolonged period of convalescence and by frequent recurrence of pains, while yellow fever is shorter in duration, with more rapid convalescence, and freedom from recurrences of pains. From the above-named considerations I have no hesitancy in avowing that yellow fever and dengue are radically and essentially different diseases. It is true that dengue often prevails concurrently with, or precedes, or follows, an epidemic of yellow fever, but in my opinion these epidemic visitations simply indicate coincidences of time and locality.

The Relation of Dengue to Malarial Fevers.—There is no evidence to demonstrate that these diseases are related otherwise than in time of prevalence and geographical distribution. However, dengue prevails where malarial fever is unknown. In the epidemic of 1880 cases were seen at Summerville and Aiken, S. C., where, according to the local physicians, malaria does not occur. The thermometrical observations, together with the arthritic and muscular pains, eruptions and glandular enlargements of dengue, will readily establish the differential diagnosis. The cachexia of malaria is also an important diagnostic point. Detection of Laveran's Plasmodium malariæ will, of course, establish the existence of malarial fever.

From acute articular rheumatism dengue differs in that effusions into synovial cavities are extremely rare, while peri-articular enlargements frequently accompany or follow the disease. The pain is not confined to the joints, as in articular rheumatism, but extends to the head, back, and limbs. The inflammatory processes in the heart or its coverings, so frequent in rheumatism, are almost unknown in dengue. The physical, mental, and nervous prostration of dengue is also almost unknown in rheumatism. Finally the eruption, the enlargement of the lymphatic glands, and the epidemic nature of dengue add to the certainty of diagnosis between dengue and articular rheumatism. From muscular rheumatism dengue is to be differentiated by the more localized fixation of the pains in the former, and by the symptoms of dengue above given.

From scarlatina dengue may readily be diagnosticated. These diseases in the beginning have great resemblance, but they may be diagnosticated by the intense muscular and arthritic pains, and glandular enlargements of dengue, and the diversified eruptions of scarlet fever.

Complications are comparatively rare. Abortion in pregnant women and convulsions among children were the most important complications met with in the epidemic in Augusta in 1880.

Sequelæ.—Marked mental and physical prostration, persistent and annoying insomnia, over which narcotics had not the usual control; anæmia, palpitation of the heart, with no organic disease thereof; marked nervousness, trying and debilitating neuralgias, severe diarrhœa, furuncles, abscesses, partial paralysis of one or more of the limbs, etc., constituted the sequelæ of dengue, as observed in my practice. In the practice of some of my friends insanity, which persisted for several months, was in three instances observed in aged subjects.

TREATMENT.—Quinine is claimed to be a prophylactic against dengue when taken in doses of from ten to fifteen grains daily. From this view I most unqualifiedly dissent. I tested it in my own person—took from ten to fifteen grains daily for about two weeks—and at the very time when my system was thoroughly and unpleasantly saturated with quinine, I was taken ill with dengue of marked febrile intensity, the temperature on the second day reaching 105⅞° F. I have witnessed repeated failures of the alleged prophylactic powers of quinine in this disease.

Some writers, believing in the contagiousness of dengue, demand isolation of the sick, disinfection of infected clothing, bedding, etc.—in short, such preventive measures as are enforced against smallpox, scarlet fever, and other contagious diseases. I am by no means satisfied that this is a contagious disease. If, however, in future it be demonstrated to be contagious, and amenable to isolation and disinfection, we need never expect to see these preventive measures put in operation against it. It being almost invariably a non-fatal disease, the average citizen can never be induced to adopt preventive measures, even if such were definitely known.

While it is true that we know of no preventive measures nor prophylactic medicaments against dengue, it is unquestioned that judicious symptomatic treatment can do much to abbreviate the disease, or at least mitigate the high fever and extreme suffering which so debilitate and emaciate the patient.

One of the first and most important indications for treatment in severe cases of dengue is to repress the fever. For this purpose antipyretics, in the form of warm baths, packings or spongings, and the internal administration of drugs which are known to have the power of reducing fever, are to be resorted to. Either of these methods, or a combination of them, will be found serviceable in the treatment of this disease. A very high temperature is not infrequently observed in dengue. I have several times seen it reach 106° F. The hydropathic treatment will be found advantageous in these cases. Some physicians prefer a cold bath, *i.e.*, from 60° to 70° F., for periods of ten minutes, and repeated or not according to circumstances. I am not an advocate of the cold bath. I have seen great damage, in the form of shock, result from the cold bath when used in typhoid and other fevers. I prefer, and have used with marked benefit, in dengue and various febrile diseases, the warm or hot bath. If the temperature of the body is 104° F., I use the bath at a temperature of 99° to 101° F., thus abstracting from three to four degrees of heat, and thereby avoid the risk of shock so imminent when the cold bath or pack is used. Hot foot-baths, frequently repeated, will often reduce the fever two degrees, and greatly relieve the head symptoms. Sponging the body with cool or tepid water, for ten to twenty minutes at a time, and repeated if it seems to be required, will likewise reduce the fever. In treating children in this and other febrile diseases, the prompt reduction of the fever is necessary to prevent convulsions.

Of the various drugs administered for antipyretic effect, I know of none equal to quinine. I am aware that some observers deny its efficacy, but the failures are due rather to the method of using the medicine than to its lack of energy. To obtain the antipyretic effects of quinine it must be given in large doses, *i.e.*, gr. xxx. to xlv., within from two to four hours, to adults, and to children proportionate doses according to age. Within six hours after taking full doses of quinine, a marked diminution of the fever will be verified by the thermometer, and in twelve hours the reduction of heat to the minimum will have occurred. The effects of large doses of quinine usually persist for from twelve to twenty-four hours. Even in typhoid fever such doses of quinine will rarely fail to reduce the temperature two or three degrees. The repetition of the drug is to be indicated by the height and persistency of the fever. It is only in severe cases of dengue that this treatment will be necessary. Another important indication for treatment in dengue is the mitigation or relief of pain. Hypodermics of morphine act more promptly and lastingly than any other method of exhibiting the drug.

When arthritic pains are severe, administration of morphine with salicylate of sodium, together with counter-irritation to the spine and seat of pain, is indicated.

Hydrate of chloral with bromide of potassium should be given for insomnia.

Threatened abortion, nasal and other hemorrhages, diarrhœa, convulsions, etc., are to be treated upon general principles.

The practice of indiscriminately prescribing purgatives is to be condemned. In my experience, troublesome diarrhœa is frequently encountered in the later course of dengue.

Mental aberration following dengue is generally caused by anæmia or insomnia, and is to be combated by hypnotics, chalybeate tonics, and full and nutritious diet.

Eugene Foster.

DENTITION, DISORDERS OF.—A distinguished authority upon children's diseases recently expressed to the writer decided incredulity regarding the propriety of the nosological distinction implied by the above title. This gentleman doubtless gave expression to the view held by a large proportion of the medical profession, in accordance with which morbid conditions other than those confined to the buccal cavity are in no sense dependent upon perverted dental evolution, and their appearance, during teething, is a pure coincidence. The writer believes that the wide prevalence of this doctrine is susceptible of easy explanation by the application of the psychological principle underlying all reactions from extreme erroneous opinions. Our great-grandfathers unnecessarily bled their patients to the verge of syncope. Our fathers, warned by the demonstrated inefficacy of their ancestors' methods, abjured the use of the lancet. The present generation, wisely adopting the golden middle course, regards phlebotomy as a dangerous, yet valuable, therapeutic resource. Again, the success which homœopathy at first attained may be considered a protest against the officious interference of early practitioners with the beneficent and efficient *vis medicatrix naturæ.* And these examples might be multiplied to show, by analogy, how the current professional scepticism regarding the existence of constitutional disorders bearing to teething the relation of effect to cause is a logical sequence of exaggerated notions, still prevalent with the laity, concerning the potency of dentition in the causation of disease. This modern incredulity has subserved an extremely useful purpose by calling attention to the fact that comparatively few constitutional disturbances are really dependent upon teething, and in doing away with the erroneous belief that the checking of these disorders would exert a harmful effect upon the natural course of dentition. Dr. J. Lewis Smith remarks, in regard to this subject:[1] "Every physician is called, now and then, to cases of serious disease, inflammatory and others, which have been allowed to run on without treatment in the belief that the symptoms were the result of dentition. I have known acute meningitis, pneumonia, and entero-colitis, even with medical attendance, to be overlooked during the very time when appropriate treatment was most urgently demanded. Many lives are lost in this manner, especially from neglected entero-colitis, the friends and physicians believing the diarrhœa to be symptomatic of dentition, a relief to it, and therefore not to be treated. Such mistakes are traceable to the erroneous doctrine, once inculcated in the schools and still held by many of the laity, that dentition is, directly or indirectly, a common cause of infantile diseases and derangements." Dr. Yale aptly says:[2] "The difference of opinion is, then, not a simple dispute of terms, but one which has a real interest in the nursery. If the parents believe that dentition causes all the ailments attributed to it, they are, as we daily see, prone to consider the ailments as nearly, if not quite as much, a matter of course as the natural teething process, and they consider it useless to try to cure them until teething is complete. As a result of all these errors and confusions, it too frequently happens that disorders which might have been very tractable at the outset are allowed to progress unopposed, until they reach a serious stage. If, on the contrary, we assume that teething is rarely the real cause of disease, the parent will seek some other reason for any disturbance of the system that may exist, and will endeavor to remove it."

Dr. Holt says[23]: "Speaking from impressions, not from statistics, I should say that, in my experience, about one-half of the healthy children cut their teeth without any visible symptoms, local or general; in the remainder some disturbance is usually seen, and though, in most cases, it is slight and of short duration, it may last for several days or even a week." In discussing the place of dentition as an etiological factor in children's diseases, Dr. Holt further writes: "At the present time many good observers deny that dentition is ever a cause of symptoms in children; some even going so far as to say that the growth of the teeth causes no more symptoms than the growth of the hair.

"Although I strongly believe that the importance of dentition, as an etiological factor in disease has, in the past, been greatly exaggerated, and although I have formerly held the opinion that simple dentition did not and could not produce symptoms, within the past few years I have been compelled by clinical observations to change my opinion upon this subject; and I am now willing to admit that dentition may produce many reflex symptoms, some, even, of quite an alarming character."

Having thus clearly indicated, by the above quotations, the cogent reasons for the exercise of caution in attributing to dentition an active agency in the development of any constitutional disease occurring coincidently with it, the writer still advocates the retention of the term *disorders of dentition*. This he does because, in the opinion of many competent observers, functional and organic ailments *do* sometimes occur at points remote from the seat of morbid local processes incident to teething, as the result of these processes, although none of the disorders in question can be regarded as peculiar to dentition.[3] It would indeed seem equally proper that the collective title of these diseases should indicate the etiological relations existing between them and the processes of dentition, as, for example, that the disorders incident to utero-gestation should bear the generic name, "Diseases of Pregnancy," although each individual affection embraced under this heading may at times be developed in connection with various morbid processes instead of simultaneously with a single physiological one. The writer, therefore, designates by the title *disorders of dentition* all morbid states, whether local or general, which are visibly dependent upon local deviations from the normal course of physiological dentition.

The disorders of dentition embrace: I., Anomalies of Development, and II., Disorders of Eruption. Under the former head are included anomalies relating to the time of the eruption of the teeth, to their number, their position, their direction, their form, and their texture, or their structure. These anomalies deserve attention as constituting frequent exciting causes of the disorders of eruption. The disorders of eruption may manifest themselves either at the first, or, more rarely, at the second dentition, being either local, and due to the direct irritant effect of perverted dental development, or sympathetic, and produced by the intervention of reflex nervous mechanisms.

I. ANOMALIES OF DEVELOPMENT.—1. *Anomalies in the Time of Eruption.* Dentition is sometimes notably retarded in rachitic, strumous, syphilitic, and tuberculous children, or in those suffering from marasmus induced by chronic or acute disease. Malformations of the jaw also constitute a rare cause of delayed dentition. "The evolution of the teeth," says Dr. William H. Day,[4] "tests the vigor of the child, and the more tardy and lingering the process, the less its strength and vitality." In some unusual cases the first teeth have not appeared until the third year, or even later. Steiner[5] reports a case in point, observed by himself, in which the eruption of the teeth did not occur until the child was four years old. The milk teeth may, on the other hand, be prematurely developed, even attaining their complete growth before birth, as in the cases of Louis XIV. and of Mirabeau, but their roots are generally rudimentary, and they soon fall out or decay, while early dental development is not an indication that the growth of the entire organism will be more rapid or vigorous than usual. Cases have, however, been reported[6] in which deciduous teeth, especially the canines and molars, were present and well preserved in persons thirty years of age or upward. In these cases the dental follicles of the permanent teeth were either never developed or remained rudimentary.

Irregularities in the ordinary succession of the teeth are sometimes observed, the upper incisors, usually the lateral ones, appearing before the lower incisors, and, very infrequently, the canines before the molars. Albrecht is of the opinion (*loc. cit.*) that cases of reputed third dentition are best explained by the assumption that certain teeth may be retained in the jaw until the atrophy of the alveolar process, incident to advanced age, exposes the previously hidden alveoli. Should the eruption of the teeth be delayed beyond the ninth month, diligent search for the cause of the retardation of dentition must be instituted, and, if possible, appropriate remedial measures promptly adopted.

2. *Anomalies in Number.*—In certain rare cases, alluded to by Charles Sarazin,[7] neither deciduous nor permanent teeth were ever developed. This fact was, perhaps, referable to entire absence of the elementary dental follicles, or to their early destruction by alveolar disease. Symmetrical absence of two incisors, canines, molars, or wisdom teeth has been reported, but failure in development of a given pair of deciduous teeth does not necessarily presuppose a similar deficiency in the permanent set. On the other hand, the first set may be complete, and the second deficient. *Supernumerary teeth*, either deciduous or permanent, are frequently observed. Their development may sometimes be due to accidental segmentation of a primary dental follicle,[8] or, again, to the existence of supernumerary follicles. Supernumerary teeth of the first dentition are generally developed in positions not normally occupied by teeth, and are distinguished from prematurely developed permanent teeth by their relatively small size, and by their conical crowns. Supernumerary teeth of the second dentition, which closely resemble the supernumerary milk teeth as regards size and shape, often appear at an earlier date than the permanent teeth, and may usurp the place of the latter, which are consequently forced into an unnatural position. They frequently, however, make their appearance between the first incisors or to the inner side of the latter. Sometimes they perforate the palate bone in the vicinity of the wisdom teeth. On account of their abnormal position, these teeth may injure the tongue and interfere with articulation, in which case their removal is urgently indicated.

3. *Anomalies in Position and Direction.*—These anomalies are occasioned either by the development of the rudimentary dental follicles in an abnormal position, or by the interposition of some obstacle in the path of the normally located follicle, by which the latter is forced to assume an unnatural position. The latter cause affects the deciduous teeth only. If the former cause be operative, the teeth may be developed far from their natural site, the wisdom tooth of the lower jaw sometimes appearing in the ascending ramus, even so high as the border of the coronoid process or near the condyle, and the teeth of the superior maxilla effecting their exit in the centre of the hard palate, or even occasionally projecting into the nasal fossæ. Dentigerous cysts occur in various situations remote from the jaw, notably in the ovaries. The *direction* of the teeth becomes faulty when obstacles oppose themselves to the growth of the permanent set. These obstacles may consist of milk teeth which have too long retained the places destined for their successors. Again, a milk tooth may have been removed before the permanent one was sufficiently matured to take

its place. Under these circumstances the deciduous tooth follicle may have become ossified, thus erecting an impassable barrier before the tardily developed permanent tooth. In still other cases abnormal narrowness or shortness of the alveolar border may cause the teeth to deviate from their natural direction, and the same result may be produced by a faulty direction of the entire alveolar process. Reference should here be made to an anomalous position sometimes assumed by the root of a deciduous tooth, at the time of the second dentition. If teething progress naturally, this root is gradually absorbed over its entire surface by the advancing permanent tooth, which thus gradually effects the extrusion of its predecessor. Should the advance of the permanent tooth be irregular, uniform absorption of the deciduous root does not occur, and the root, pressing against the alveolar process, causes absorption of the latter, presents itself on the lateral surface of the process, and, by constant friction and pressure upon the neighboring soft parts, causes inflammation and ulceration of the gums, the tongue, or the cheek. The direction of the teeth should be either vertical or slightly inclined inward, the superior incisors overlapping the inferior ones. The operation of either of the last-mentioned conditions may cause all the inferior incisors to project beyond their fellows of the upper jaw, the canines and bicuspids being inclined outward (lateral deviation). The opposite condition, viz., inversion, sometimes obtains. These deformities affect individual teeth alone, provided the obstacle be a single milk tooth, too long retained in its socket, or the ossification of a vacant deciduous follicle. Single teeth may even be twisted in such a manner as to stand at right angles to their normal positions.

4. *Anomalies in Size and Form.*—An entire tooth occasionally attains abnormally large dimensions, thus occasioning displacement of its fellows. The crown may be alone hypertrophied, or the root be sinuous and unusually elongated. In rare instances, certain teeth are so distorted as not to present a vestige of their natural form. Several adjoining teeth, usually the incisors, may be united throughout and covered by common coats of enamel and of cement. Abnormal divisions of single teeth are also rarely encountered.

5. *Anomalies in Structure.*—Histological anomalies of the milk teeth are generally referable to morbid constitutional conditions, such as struma and rachitis, leading to perversion in dental development, and affect either the enamel, which may be soft, opaque, thin, crumbling, and even absent, or the ivory, which is abnormally friable, although often of unnatural thickness, and is very prone to decay. Acute infantile diseases, particularly the exanthemata and typhoid fever, the abuse of mercurials, and stomatitis, occasion morbid histological changes in the permanent teeth, which being inadequately supplied with enamel, are soft and inclined to decay, are furrowed horizontally, separated by abnormally wide intervals, and present a repulsive yellow discoloration. The most interesting pathological processes affecting the permanent teeth are produced by congenital syphilis, and were first exhaustively studied by Mr. Hutchinson, with whose name the appearances about to be described are inseparably associated.[9] Syphilitic teeth may present any or all of the changes described above as incident to various infantile diseases. The incisors, and sometimes the canines, may also be deformed and dwarfed, being "narrow, rounded, and peg-like, their edges jagged and notched." The morbid conditions pathognomonic of inherited syphilis are, however, positively characteristic, and affect, according to Mr. Hutchinson, the permanent median upper incisors, which often present the peculiar syphilitic deformity when the other incisors are of normal shape. M. Fournier is, however, said by Dr. J. William White[10] to believe that the deciduous teeth are affected by syphilis exactly as are the permanent ones, but that the disease is overlooked in the majority of cases. The characteristic syphilitic teeth are separated by an unnaturally wide interval, but their crowns are generally convergent, rarely divergent. The teeth are abnormally short and narrow, their corners are rounded, and they present a broad vertical notch at their edges, at the bottom of which the dentine is exposed. Sometimes a shallow furrow passes upward from this notch, on both the posterior and anterior surfaces of the tooth, reaching nearly or quite to the gum. The anterior surface of these teeth looks upward. They are of crescentic form, their convexity being also directed upward. The teeth may present the appearances characteristic of mercurial poisoning simultaneously with the lesions due to syphilis. Dr. Thomas Barlow and M. C. MacNamara[10] state that only one of the upper central permanent incisors may be characteristically deformed, the other being normal or presenting diseased appearances not peculiar to syphilis. These authors also emphasize the facts that the pathognomonic syphilitic tooth possesses a single vertical notch, and not a serrated border, and that "the existence of normal, permanent upper median incisors by no means excludes the existence of hereditary syphilis." Constitutional treatment, appropriate for syphilis, should be promptly adopted as soon as the diagnosis of syphilitic dental disease is fully established.

II. DISORDERS OF ERUPTION.—A. *Local Disorders of the First Dentition.*—We may better appreciate the nature of these morbid processes and their adequacy to the excitation of reflex nervous phenomena by recalling some of the abnormal conditions occasioning them.

Any unusual obstacle to the eruption of the first teeth is capable of leading to morbid local processes. Among these obstacles may be mentioned narrowing of the dental furrow and alveoli by the approximation of the labial and lingual borders of the alveolar process. This may be occasioned by the compression of these comparatively yielding structures, especially in rachitic children, by the constant activity of the tongue and lip muscles. The gum may also be abnormally thick and of cartilaginous density. In either case, the growing tooth, encountering an unnatural obstruction, exerts abnormal pressure upon the exquisitely sensitive branches of the fifth nerve, in its matrix, and occasions odontalgia, which may become exceedingly severe. Inflammation of the follicle, resulting from congestion in the matrix, is also produced by the abnormal pressure of the tooth, and may result in gingivitis, ending in ulceration and complicated by severe stomatitis. In mild cases the inflammation does not reach so extreme a degree, and results only in slight exaggeration of the normal local inflammatory changes elsewhere enumerated, and often incident to the simultaneous eruption of several teeth, with, possibly, otalgia, fever, and some of the milder reflex phenomena soon to be described. In the worst cases, however, alveolar periostitis, even of sufficient gravity to occasion necrosis of the alveoli and destruction of the teeth, and submaxillary and cervical adenitis and abscess of the cheek may be observed. The ordinarily mild local phenomena then give place to those characteristic of the above-mentioned inflammatory process. The gums are swollen and tense, or ulcerated and sloughing, the tongue and buccal mucous membrane are swollen and hyperæmic, or sometimes aphthous and ulcerated, the cheeks are red and tumefied, the saliva is abundant and ropy. The child has a remittent form of fever attended by jactitation, insomnia, and anorexia, or by somnolency and asthenia.

B. *Sympathetic Disorders of the First Dentition.*—The principal diseases usually embraced under this title are enteritis, gastro-enteritis, entero-colitis, otitis, conjunctivitis, coryza, bronchitis, cutaneous eruptions, such as urticaria, herpes, eczema, and prurigo, retention or incontinence of urine, dysuria, nervous cough, laryngismus stridulus,[11] subsultus tendinum, and eclampsia. Many authors deny that dentition plays any essential rôle in the production of the disorders just enumerated, unless there exist a predisposition to their development. The nature and cause of this predisposition are not generally more closely defined, but are inferentially stated to consist in a dyscrasia, or diseased constitutional state. West says, in this connection:[12] "The period of teething, like that of puberty, constitutes one of the great epochs of life; it is a time when great changes are going on in the whole organism,—when, the animal machine being in a state of increased activity, its parts are more than usually apt to get out of order. Statistics embracing the largest numbers prove the dangers of this period. . . . The error which has been committed with reference to this matter, not merely by the vulgar, but by members of our own profession also, consists not in overrating the hazards of the time when changes so important are being accomplished, but in regarding only one of the manifestations —though that, indeed, is the most striking one—of the many important ends which nature is then laboring to bring about. The epoch of dentition is to be looked at just in the same way as that in which we regard the epoch of puberty. Constitutional disturbance is more common, and serious disease more frequent at these times than at others; but their causes lie deeper than the tooth which irritates the gum that it has not yet pierced, in the one case, or than the womb which has not yielded the due discharge of blood, in the other." The writer admits that these diseases may, in many cases, especially in those attended by slight local inflammation, be entirely accidental complications of dentition, the gastro-intestinal disorders being, for instance, referable to insufficient or improper food, great summer heat, and to the development of the digestive tract, and the cutaneous diseases to hereditary predisposition. In the graver forms of disease, however, the writer believes that the local inflammation due to perverted dental development itself plays the part of both predisposing and exciting cause of the sympathetic disorders. Some of the above-mentioned diseases cannot, perhaps, lay valid claims to the title of sympathetic disorders, but may be due to extension of inflammation from contiguity of tissue. This remark might apply to coryza, otitis, conjunctivitis, and, possibly, to the bronchitis.

Vogel[13] refers the bronchitis to the wetting of the chest by dribbling saliva, and the diarrhœa to the laxative effect of the saliva which is swallowed; but this view is opposed by the fact that these symptoms occur when the chest has been well protected, and when the quantity of saliva is not excessive. Throwing the diseases possibly due to extension of local inflammation out of account, we must still explain the etiology of the graver sympathetic nervous disturbances, above enumerated, and the occurrence of those ailments sometimes due to extensive inflammation when the latter causation cannot be demonstrated.

The writer is of the opinion that their predisposing cause lies in the gradual depreciation of nervous energy by the continued local irritation, and that the influence directly precipitating them is a nervous reflex act, the centripetal impression for which is conveyed through the exquisitely sensitive fifth pair, and is converted, at the motor or vaso-motor centres, into centrifugal impulses affecting the organs in which the sympathetic disease is located.[14]

Barrier refers eclampsia, when excited by dentition, to the causes just assigned by the writer, and, in addition, to the participation of the whole cerebral vascular system in the hyperæmia existing around inflamed dental follicles. The enumeration of the symptoms constituting the clinical history of the sympathetic diseases of teething would entail useless repetition of details to be found in the articles, in this HANDBOOK, descriptive of these affections, since their course is essentially the same as when they are not complications of dentition.

The general character of the graver nervous phenomena may, however, be alluded to. The convulsive movements either affect isolated groups of muscles or are general. They vary greatly in severity, and either occur suddenly or are preceded by premonitions, such as unusual restlessness, fretfulness, and general discomfort, together with evidences of great local disturbance. The attacks are single or multiple. In the latter case the intervals are of variable duration. The entire paroxysm may be limited to a few minutes, or may be protracted over several days. One of the milder types of eclampsia consists in such a contraction of the facial muscles that a smiling expression of countenance results. In other cases the respiration is merely quickened, the pupils dilate, the eyes assume a staring aspect, and the face grows pale or livid. In graver cases laryngismus stridulus occurs, and all the muscles may be successively or simultaneously tetanized. The circulation and respiration are obstructed, and asphyxia, cerebral congestion, or syncope may entail a fatal issue. A lethal result is usually produced by a series of paroxysms rather than by a single convulsion. Partial paralysis, idiocy, strabismus, and cerebro-spinal meningitis are stated to have sometimes followed eclampsia, but their etiological dependence on the convulsions is not established.

DIAGNOSIS.—Since the constitutional diseases induced by dentition are often referable, even when developed simultaneously with teething, to other causes, these must be diligently sought in every doubtful case. If no morbid condition of the gum or of the jaw be discoverable, the inference that the disease in question is due to other causes is justifiable. Should the disorder, however, manifest itself at each epoch of dental eruption, subsiding after the completion of the latter process, its etiological dependence upon dentition will be unmistakable.

Treatment.—This embraces prophylactic and curative measures, which are either local or general. 1. Local prophylaxis consists in frequent cleansing of the buccal cavity with a solution of borax containing gr. xx. to an ounce of water, or some similar detergent lotion, in order to prevent thrush or simple stomatitis; in gentle friction of the inflamed gums with the ball of the finger, a smooth bone, or the smooth handle of a silver spoon; and in providing the little patient with a harb-rubber object for the maxillary gymnastics to which he is naturally inclined.

2. General prophylaxis. This aims at the maintenance of the general health, and embraces all required hygienic measures. The child should spend a large part of the day in the open air, whenever the weather is suitable. The diet should be carefully supervised, and especial attention given to the care of the bottles of hand-fed babies. Too frequent nursing must be discountenanced. The bowels should be regulated, rhubarb and calomel and enemata being used for constipation, and chalk mixture, with bismuth subnitrate and a few drops of *tr. opii camph.* in each dose, in case of diarrhœa. Salol, either alone or in combination with the remedies just mentioned, has, in the writer's experience, proved very efficacious in checking diarrhœa or tympanites. If flatulence exist, a carminative, preferably a mixture of *spts. lavand. co.*, *spts. card. co.*, *syr. zingib.*, and *aq. menth. pip.*, in equal parts, should be employed in ♏x. to xx. doses. If there be considerable febrile disturbance, *spts. æther. nitrosi*, in doses of ♏x. each, may be administered to a child one year old, or tincture of aconite, *gtt. ss.–i.*, may be given, at intervals of one hour, until from four to six doses have been taken. Restlessness and jactitation may be best combated by a mixture containing bromides. Dr. Day[15] recommends the following formula:

℞ Potass. bromid	gr. ij.
Potass. iodid	gr. ¼.
Spts. ammon. aromat	♏ ij.
Syrup	♏ xx.
Aquæ	q. s. ad fl. ʒ i.

M. Sig.: To be taken every four hours. For children one year old.

Small doses of phenacetin, phenocoll, or antipyrin may properly be employed, in many cases, instead of the bromide mixture suggested by Dr. Day.

With a view of diminishing cerebral congestion, and thus preventing eclampsia, Vogel[16] recommends affusions of cold water, repeated at intervals of from one to two hours, and Espine and Picot[17] extol tepid baths for the fulfilment of the same indication. The head may properly be bathed, in common with the rest of the body, and warm head coverings should be discarded.

3. *Local curative treatment* is required for the relief of

aphthous ulcerations of the buccal mucous membrane, rarely for abscesses in the buccal parietes, for inflamed and painful gums plainly rendered so by obstructed dental eruption, and for alveolar periostitis. Ulcerations of the mucous membrane require strict cleanliness, obtained by thorough rinsing of the mouth with tepid water, and by the use of lotions containing ten grains of borax to an ounce of glycerin.[18] West[19] approves the internal use of potassium chlorate, in doses of gr. iv. every four hours, for a child aged one year. In graver forms of ulceration, nitrate of silver solution, containing fifteen grains in an ounce of water, may be painted over the ulcerated surfaces, and leeches may be applied at the angle of the jaw. Peroxide of hydrogen or permanganate of potash may also be employed as a mouth wash. Abscesses in the cheek must be promptly evacuated. Very painful and inflamed gums are best and quickest relieved by free incisions, executed with a scalpel, a lancet, or a curved bistoury, so guarded as to avoid injury to any but the inflamed parts. The lancet is not to be used save for good and sufficient reasons, but must be wielded with decision, if required at all. The child's head is held between the knees of the operator, the jaws being kept open by his disengaged hand. The incisions should extend quite down to the tooth, and should be longer than the advancing dental crown. The cuts should be crucial for the molars and linear for the cuspids. Sometimes a wedge-shaped piece of the gum may be advantageously removed, if this be the offending tissue. If severe alveolar periostitis exist, the dental follicle may have been so far disintegrated as to have occasioned necrosis of the tooth, which must then be extracted. The measures just described effect almost immediate relief of local symptoms by reduction of tension in the inflamed tissues, and by their depletion. In children of an hemorrhagic diathesis the lancet must be avoided, and reliance placed in the local and general preventive and curative treatment. If the above measures be adopted as soon as the gums are markedly inflamed, the graver sympathetic disturbances will usually be averted. Hence, lancing of the gums is both curative of the local morbid state and prophylactic as regards the sympathetic affections of dentition. For local preventive and curative treatment of otitis, conjunctivitis, coryza, bronchitis, cutaneous eruptions, and incontinence or retention of urine, consult the articles in this HANDBOOK treating of these subjects.

4. *General Curative Treatment.*—The therapeutic measures embraced under this head are intended to take the place of local surgical interference with the gums, when the condition of the latter is not such as to warrant the use of the lancet. These measures must be directed to the cure of whatever constitutional symptoms appear in a given case, and are identical with those required for the relief of similar symptoms when not complicating dentition. The reader is, therefore, again referred to the appropriate articles in this HANDBOOK. The bromides and chloral are second only in value to incision of the gums, in the convulsions of dentition, and are employed with great benefit in cases not adapted to the use of the lancet. Five grains of the bromide of potassium may be given to a child one year old, by mouth, or ten grains by rectum, if the patient be unable to swallow, and the dose repeated every quarter of an hour until the convulsions cease, after which occasional doses may be given as required. At the respective ages mentioned, equal quantities of chloral, dissolved in one-half ounce of lukewarm water, should be given by the rectum, if the bromides have no effect, and may be repeated after an hour, if necessary. Chloroform may be cautiously given, by inhalation, to control the convulsions until a sufficient quantity of the bromide and chloral has been absorbed to fulfil this indication. Cold to the head, hot mustard baths, a cathartic, preferably castor oil, and warm laxative enemata, are valuable adjuvant therapeutic agents.

C. THE LOCAL DISORDERS OF SECOND DENTITION.—*Etiology.*—The chief cause of these local diseases which, although rare, greatly predominate over the sympathetic or constitutional disorders of second dentition, is obstruction to the natural eruption of the permanent teeth. The chief obstacles to eruption are either deciduous teeth which have been too long retained, ossification of deciduous follicles from which the teeth have been too early removed, or narrowness or shortness of the alveolar border, by which the advancing teeth are forced from their natural positions and obliged to effect their exit through bony tissues instead of through the gum, in the direction of their alveoli. Faulty direction of the original follicle, its development in an abnormal position, fibroid induration of the gum, and the growth of supernumerary teeth are other causes of obstructed eruption. Any of the primary teeth may encounter these obstacles, but the so-called *dentes sapientiæ*, or third molars, are peculiarly liable to do so, since the remaining teeth have attained their full development at the time of the appearance of the wisdom teeth, and in many cases have encroached upon the latter's domain. The wisdom teeth of the inferior maxilla are, from their position in proximity to the ascending ramus and the consequent limited space afforded them for development, usually the starting-points of the morbid processes about to be described.

Symptoms.—Encountering one of the obstacles just mentioned, the teeth are directed either against the neighboring teeth or against the cheek or the tongue, and excite either simple ulcerative or suppurative stomatitis, glossitis, gingivitis, or cervical adenitis, while the excessive pressure within the follicles may occasion alveolar periostitis, exostosis,[20] osteitis, and caries or necrosis of the teeth themselves. These diseases of the jaw and teeth apparently owe their origin, in some cases, to extension of the inflammatory process from the gums to the osseous structures, rather than to excessive pressure within the follicles. Should abscesses, developing in the gums, tongue, or cheeks, be left to nature's direction, the pus effects its exit either into the buccal cavity or upon the surface of the cervical or maxillary regions. In some cases the purulent matter may widely infiltrate the subcutaneous or intermuscular cellular tissue of the cervical region, producing sinuous sinuses and fistulæ. Other and rarer inflammatory complications of the second dentition are tonsillitis, pharyngitis, otitis, rhinitis, conjunctivitis, and cervical erysipelas. The symptoms of these diseases need not be here enumerated, and allusion will be merely made to the difficulties of articulation and mastication, to the dysphagia, the deafness, otorrhœa, coryza, profuse salivation, and the febrile disturbance which may result from the inflammatory conditions above referred to.

D. SYMPATHETIC DISORDERS OF THE SECOND DENTITION.—The principal sympathetic diseases incident to the second dentition are neuralgia of the fifth nerve, which, beginning as an odontalgia in the affected teeth, may develop into hemicrania, tic douloureux, or spastic contraction of the muscles of mastication, leading to a tight closure of the jaws. Other and rarer reflex disorders, included by some authors in this category, are facial paralysis, nystagmus,[21] otalgia, aphonia, hysteria, tetanus, chorea,[21] and even epilepsy.[22]

Treatment.—1. Prophylactic: With a view to the prevention of ossification of deciduous follicles and consequent obstruction to the exit of permanent teeth, the milk teeth should be prevented from decay by appropriate hygiene, and if carious, should be filled, instead of being early extracted. Supernumerary permanent teeth, or those developed from misplaced original follicles, should be removed before their pressure shall have displaced the growing regular teeth, or shall have exerted injurious pressure on the soft parts. If the jaw be too small for the accommodation of a full set of permanent teeth possessing normal dimensions, or should unnatural size of certain teeth lead to injurious pressure, a sufficient number of teeth must be sacrificed to make room for the remainder. If ossification of a deciduous follicle be the cause of detaining a permanent tooth in the alveolar process, the only resource is the trephine, after which extraction of the included tooth may become necessary.

2. Curative treatment: Prompt and efficient local treatment will, in most cases, speedily relieve both the local

and the sympathetic disorders of the second dentition. Should the root of a deciduous tooth prove to be the obstacle to the exit of its successor, it must be at once extracted.

If the gum, over a wisdom tooth which is about to make its appearance, be seriously inflamed or ulcerated, it should be incised or partially excised, the borders of the incision being then cauterized, in order that immediate union shall not occur. Should the crown of the tooth be carious, or its direction so abnormal as to threaten injury to the tongue or lips, the tooth must be removed. If it be impossible to find the *dens sapientiæ* after incision of the gum, owing to its deep inclusion in the alveolar process, the second molar may be removed and place thus be made for the advancing wisdom tooth. In the event of the formation of abscesses, in the cheek, the gum, the tongue, the cervical connective tissue, or the cervical glands, they should be promptly opened. The remaining possible inflammatory and reflex complications of the second dentition, enumerated above, are to be treated, after the adoption of the local measures advised, in accordance with the principles enunciated in the appropriate articles of this HANDBOOK. The spastic contraction of the jaws, already alluded to, occasionally simulates trismus, sometimes greatly interferes with the local treatment, and may best be overcome by anæsthesia.

William H. Flint.

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[14] J. Lewis Cohen: Dis. Mouth and Tongue, Pepper's Syst. Prac. Med., vol. ii., p. 374, 1885.
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[16] Dis. Children, Raphael's Translation, p. 107, New York, 1873.
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[19] *Op. cit.*, p. 457.
[20] Thos. H. Tanner: Prac. of Med., p. 316, Philadelphia, 1866.
[21] Magitot, Littré et Robin, Dict. de Méd., p. 432, 1873.
[22] Tanner: *Loc. cit.*
[23] L. Emmett Holt: The Dis. of Infancy and Childhood, p. 243, 244.

DENVER.—The city of Denver, Colorado, latitude 39° 45′ N., longitude 105° W., lies upon the South Platte River, 35 miles from the main range of the Rocky Mountains, and 14 miles east from their outlying foothills—on the western limit of the great plains which stretch away to the Missouri River. Its elevation above sea level is 5,290 feet.

Besides being the capital and chief business city of Colorado, Denver is the most important railroad and distributing centre for the entire Rocky Mountain region. The city is built upon both sides of the river, but chiefly on the right bank of the stream which, flowing north, bends in the middle of the city to the northeast. The westerly bank rises in a sharp slope about one hundred and fifty feet, while on the east this elevation is not reached till about two miles from the river, the rise being gradual and easy. The immediate river valley is given over to industrial occupation, the residence districts lying to the east, south, and west. The streets are wide, and in the business portion of the city paved with asphalt, as are three of the main avenues into the residence district, where the streets are bordered by parked sidewalks shaded by trees. There are 164 miles of electric street railway reaching to every part of the city. The buildings are substantial, and throughout the city built wholly of brick and stone. The residence districts are noticeably those of homes, there being very few blocks or tenements. The public-school system is excellent and progressive, and the city is well provided with theatres and churches of all denominations. There is a good public library and a medical library of six thousand volumes.

There are five hospitals in Denver: the Arapahoe County Hospital, one hundred and eighty beds; St. Luke's (Episcopal), seventy beds; St. Joseph's and St. Anthony's (Roman Catholic), each ninety-eight beds; and the National Jewish Hospital for Consumptives. "The Home" is a beautifully equipped establishment for the reception of invalids with tuberculosis. Hotel accommodations are numerous and of a high order. The public parks have an area of five hundred acres. There is a system of public sewers which empty into the Platte River below the city. The public water is supplied by a private corporation and is of excellent quality and ample supply.

The population is about 135,000. The health of the community is good, there being a notable absence of diarrhœal and infectious diseases other than tuberculosis contracted elsewhere.

The early reputation of Denver as a health resort, especially for those suffering from pulmonary tuberculosis, has been steadily maintained, and while the rapid growth of the city and increase in industries of late years have necessarily rendered the heart of the city unsuited for an invalid, the outlying residence districts are free from contamination, and the city still holds its place among the health resorts of the Rocky Mountains.

Climatically, Denver should be classed as a high-altitude resort, with a dry, *cool* climate of considerable extremes of temperature and abundant strong sunshine.

Altitude.—Denver is one mile above sea level, and has a mean barometric pressure of 24.74 inches. It is not, however, in the mountains, but lies upon the open plains fifteen miles east from the foothills. This open situation frees it from the diurnal up-and-down draught of a mountain valley, and the long day of sunshine is unbroken by the shadows of surrounding peaks. This distinct advantage over most high-altitude resorts has a very practical relation to the daily life of an invalid. In Davos Platz, the most noted of the Swiss high-altitude resorts, which lies at the same elevation as Denver, but in a valley protected by surrounding mountain heights, the sun does not rise on January 1st till 10:03 A.M., and sets at 3 P.M. In Denver, on January 1st, the sun rises at 7:19 A.M., and does not set till 4:49 P.M., giving nine hours and a half of daylight. Speaking of Davos, Dr. Wise says: "An additional hour's sunlight during the short days of December and January is an inconceivable delight." In Denver the eastern horizon is low and level and offers no delay to the warm cheering of daylight. On December 1st the sun rises at 7 A.M.; on January 1st at 7:19, and on February 1st at 7:07. Nor is the day shortened in the afternoon, the fifteen miles "set-out" from the mountains distinctly lengthening the day.

Sunshine.—A reference to Table I., column R, will show the total number of hours of possible sunshine at Denver during each month of the year. Even in the months of shortest days, December and January, there are over nine hours and a half of possible sunshine each day.

The percentage of the total possible sunshine actually realized is high, being in the yearly average over seventy per cent. as shown by the records of the Weather Bureau over the last ten years. This large proportion of actual sunshine is quite evenly distributed throughout the year, as will be seen by Table I., columns S, T, and U, where the mean total percentage of sunshine is shown, together with the highest and lowest monthly record during the period of observation. It will be noted that the least amount obtained in any month during the ten years was 51 per cent., or over half the total possible, with the exception of the very unusual month of May, 1892, when the sunshine record was only 42 per cent. and the precipitation was 8.57 inches. A reference to Table I., columns M and N, shows that this is equally exceptional. In the other years of observation the rainfall

TABLE I.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	&
	Mean barometer in 27 years.	Mean temperature (degrees F.) in 27 years.	Highest mean temperature (degrees F.) in 27 years.	Lowest mean temperature (degrees F.) in 27 years.	Average of mean maximum temperature (degrees F.) in 28 years.	Average of mean minimum temperature (degrees F.) in 28 years.	Average highest temperature (degrees F.) in 28 years.	Average lowest temperature (degrees F.) in 28 years.	Absolute highest temperature (degrees F.) in 28 years.	Absolute lowest temperature (degrees F.) in 28 years.	Mean relative humidity in 27 years. Per cent.	Mean dew point (degrees F.).	Average total precipitation in inches.	Highest total precipitation in inches.	Lowest total precipitation in inches.	Number of times above the average in 27 years.	Number of times below the average in 27 years.	Total number of hours of possible sunshine.	Mean percentage of possible sunshine actually obtained, 1891–1899, inclusive.	Highest percentage for the month in period 1891–1899, inclusive.	Lowest percentage for the month in period 1891–1899, inclusive.	Average number of clear days in period 1891–1899.	Average number of partly cloudy days in period 1891–1899.	Average number of cloudy days in period 1891–1899.	Mean total movement of wind for the month. Average for 17 years. Miles.	Average hourly velocity. Miles.	Mean maximum velocity maintained for a one-hour period between 8 A.M. and 8 P.M. Average for 6 years. Miles.
January ...	24.73	28	38	18	41.7	15.5	61.8	−2.0	76	−29	53.8	19	0.54	2.35	0.05	9	16	301	71	80	60	20	8	3	6,141	8.3	12.9
February...	24.61	32	38	22	44.1	19.5	63.0	−1.9	77	−22	54.2	11	.53	1.22	.11	12	15	300	68	75	56	15	9	4	6,405	9.5	11.3
March	24.56	39	46	32	51.5	25.9	71.3	5.3	81	−11	50.7	16	.92	3.10	.20	12	15	371	67	73	55	14	10	7	6,692	9.0	15.2
April	24.64	47	54	41	60.4	34.7	78.1	14.2	83	4	48.4	16	1.94	4.94	.31	13	14	399	70	84	66	20	7	3	7,210	10.0	14.9
May........	24.60	57	62	52	66.0	43.9	85.3	31.7	92	27	50.0	25	2.86	8.57	.09	13	13	447	60	79	42	12	17	2	6,408	8.6	15.1
June.......	24.72	67	72	62	80.7	52.5	93.6	41.4	99	36	45.0	35	1.40	4.96	.09	11	16	449	71	77	67	15	13	2	5,876	8.2	12.8
July	24.81	72	76	67	85.9	58.5	96.7	50.3	102	42	48.1	47	1.72	4.28	.33	12	15	455	65	73	59	12	15	4	5,519	7.4	10.8
August	24.72	71	74	68	84.6	57.2	95.1	48.5	105	43	48.5	41	1.45	2.84	.33	12	14	425	70	77	60	19	9	3	5,715	7.7	10.1
September .	24.83	63	66	60	77.2	48.2	90.3	35.2	97	27	44.6	32	.79	2.89	T.	12	14	374	75	89	63	22	6	2	5,185	7.2	9.1
October	24.72	51	56	46	64.7	37.1	81.8	21.8	90	1	46.2	27	.94	3.92	.12	9	18	345	75	89	63	18	6	7	5,540	7.4	10.8
November ..	24.73	39	45	33	51.5	25.9	71.1	4.7	77	−18	49.9	20	.60	1.93	.08	10	17	300	72	81	64	23	3	4	5,800	8.1	12.4
December..	24.71	32	40	22	44.5	19.7	65.4	−3.5	74	−25	53.2	13	.66	2.32	.01	13	14	292	68	85	52	18	9	4	6,802	9.1	11.9

and sunshine records have fallen within the line of averages.

During the winter months from December to March the average percentage of sunshine obtained in Denver is 68 with a minimum record of 56, while the average obtained in Philadelphia for the same months is 37.

The average number of wholly cloudy days in a year in Denver is but 45, while 112 are partly cloudy, and 208, or six-elevenths of the entire year, are wholly clear from sunrise to sunset. The 112 days recorded as partly cloudy must not be considered unsuited for outdoor life, for the cloudiness is often light and even a grateful change from the intense brilliancy of a cloudless day. Table I., columns V, W, and X, shows the general evenness of the distribution throughout the year with the slight increase in the partly cloudy days in the spring months due to the occasional showers during that period, as will be seen by comparing the same months in column M.

Humidity.—The relative humidity at Denver is very low, being but 58 per cent. at 6 A.M., and 38 per cent. at 6 P.M., with a yearly mean of 49.4 per cent., varying in monthly means from 45 to 54.2 per cent. The absolute humidity is also very slight, being but 1.89 grains of moisture to the cubic foot. This constant dryness of the air has a decided effect upon the sensible temperature of the air, rendering the recorded heat of the summer months not comparable to similar figures in cities upon the seaboard. Evaporation from the skin is rapid in summer, leaving the body dry and cool, while in winter the same dryness of the air makes the low readings of the thermometer less realized. It affects, too, the intensity of the sunlight, causing a variation between the air and solar temperatures of from 40° to 60° throughout the year.

Temperature.—The climate at Denver is cool. The mean annual temperature is 49° F., the mean for January being 28° and for July 72°. The range between the highest mean temperature of any month and the lowest mean for the same month is not great, and is remarkably even throughout the year, as shown in Table I., columns C and D. The extremes of temperature during the year appear great, but the average variation of the monthly mean maxima and mean minima seen in Table I., columns E and F, is not great when the balancing effects of dry air and sunshine are considered. Columns E and F represent the average for twenty-eight years of the monthly mean maximum or minimum temperatures of all the days. Columns G and H, on the other hand, represent the average for twenty-eight years of the single highest or lowest temperatures recorded in the month; while columns I and J give the absolute maximum and minimum temperatures during the entire period of observation.

In comparing these three sets of columns with the mean for the month during the whole-period column, the influence of single high or low readings is discerned. For instance, in the month of January, while a maximum day temperature of 76° has been recorded and a reading of −29° may occur, yet the experience of twenty-eight years shows that the average highest temperature will be but 61.8° and the average lowest only −2°, while the average during twenty-eight years of the mean maxima for the thirty-one days of the month is 41.7° with a corresponding minimum of 15.5.° In summer a similar influence is exerted by an occasional high temperature, but in considering the absolute maximum records of July and August in column I, it should be noted that in the entire period of twenty-eight years the thermometer has been 100° or over but five times in July and only twice in August. The direct sun in summer is very hot, but the mean temperature of the air at 1 P.M. is only 85° in July, 81° in August, and 72° in September. The sensible temperature is even less, for the relative humidity of the summer months in Denver is but 46.5 per cent. as compared with 71 per cent. in Boston, 74 per cent. in New York, and 76 per cent. in Chicago. The shade is always comfortable.

TABLE II.—MEAN TEMPERATURES AT 1 P.M.

(Degrees Fahrenheit.)

1886.	Solar.	Air.	Difference.
January	92.5	27.3	65.2
February	106.3	48.0	58.3
March	107.8	41.1	66.7
April	110.6	52.3	58.3
May	141.3	74.3	67.0
June	142.2	75.1	57.1
July	146.5	85.2	61.3
August	143.7	81.5	62.2
September	132.5	72.0	60.3
October	119.5	64.2	55.3
November	100.0	41.3	58.7
December	100.2	45.5	54.7

In winter while the air is cold, perhaps for a number of

TABLE III.

	1 Mean temperature (degrees F.) for the month.	2 Mean maximum temperature (degrees F.) for the month.	3 Mean minimum temperature (degrees F.) for the month.	4 Number of times mean daily temperature was *above* the mean of the month.	5 Number of times mean daily temperature was *below* the mean of the month.	6 Highest temperature (degrees F.)	7 Lowest temperature (degrees F.)	8 Number of days on which maximum temperature was below 32° F.	9 Greatest daily range of temperature (degrees F.)	10 Least daily range of temperature (degrees F.)	11 Average variation of daily mean temperature (degrees F.) from mean of 27 years.	12 Total precipitation in inches.	13 Number of days with precipitation 0.01 of inch or more.	14 Total number of hours ACTUAL sunshine.	15 Percentage of possible sunshine actually realized.	16 Number of clear days.	17 Number of partly cloudy days.	18 Number of wholly cloudy days.	19 Total wind movement in miles.	20 Maximum velocity during any 5 minutes' record. Miles.
Bad year.—																				
November, 1898	35	48.0	22.0	16	14	74	2	4	57	10	− 4.0	0.85	7	232	77	17	10	3	5,908	50
December, 1898	26	39.3	12.3	20	10	60	−20	7	40	15	− 6	.99	4	248	85	21	7	3	6,086	38
January, 1899	30	44.3	16.6	17	13	58	− 5	1	55	16	+ 2	.65	7	232	77	18	7	6	6,731	50
February, 1899	18	31.2	4.0	15	13	56	−22	12	50	10	−14	.58	9	225	75	14	7	7	5,989	42
March, 1899	33	45.9	20.6	16	14	69	− 5	5	43	9	− 6	1.10	10	262	71	14	10	7	6,692	50
Good year.—																				
November, 1899	45	58	31.0	14	17	74	22	0	41	11	+6	T.	0	243	81	23	3	4	5,800	51
December, 1899	30	43.1	17.5	15	13	61	− 5	2	42	8	−2	.72	6	211	72	18	9	4	6,802	47
January, 1900	36	48.7	23.9	16	13	67	− 2	1	42	8	+7.7	.13	3	237	79	20	8	3	6,141	45
February, 1900	30	42.8	17.6	19	8	61	−10	5	43	9	−2	.55	6	222	74	15	9	4	6,405	53
March, 1900	43	55.9	29.6	14	16	79	14	0	43	13	+4	.63	7	264	71	20	6	5	6,113	51

days intensely so [see later paragraph concerning Table III.], it is dry and the great flood of penetrating sunshine enables the invalid to remain out of doors comfortably. The low readings of the night which are recorded in columns F and J do not affect the patient who is then housed. The marked contrast between sun and shade before noted, a difference of over 40°, is of great value in winter, for one has but to step from the cold air of the shade into the sunshine to find the great warmth of its rays, always 40° and often 60° higher. Table II. shows this difference between the solar and air temperatures and the help it offers to the invalids' outdoor life in winter.

There are many days in winter when a thin coat is sufficient in the middle of the day and but few nights in summer when a blanket is not acceptable. The clothing required in Denver is such as is worn in New York or New England, except that in winter the heaviest overcoat is less constantly needed, and in summer a light coat is necessary after sundown.

Precipitation.—Denver has an annual precipitation of less than fifteen inches, the average total for twenty-seven years being 14.35 inches. This is about one-third that of Boston or New York, less than half that of Chicago, and three-tenths that at Jacksonville, Florida. Of the total amount a little over nine inches fall during the months of April, May, June, July and August, in about even proportions each month, while the autumn and winter months from September to March inclusive divide the remaining five inches also in approximately even distribution.

Columns P and Q of Table I. show the tendency for the rainfall to be below, oftener than above the mean. In these tables the mean for May has been seriously raised by the totally exceptional rainfall of 8.57 inches in 1892, as have the corresponding figures in the calculation of sunshine. Barring this unusual year, the greatest precipitation in any May has been 4.8 inches.

The rainfall is in short downpours, a prolonged storm being the exception. Especially in summer it comes in sharp thunder showers in the late afternoon or early evening. It falls too upon a dry, porous soil which rapidly absorbs any moisture, so that within a very short time the ground is dry and hard again—the roads often being dusty within twenty-four hours after a rain.

The snowfall during the winter months is light and lasts but a short time. There is no accumulation on the ground, for the sun and dry wind evaporate it with visible rapidity without its melting into slush or icy pools. As there is no accumulation there is no long melting season in the spring to be avoided as at Davos.

The precipitation during the spring months, especially in April, is apt to come in a snow storm or heavy rain; but with the mean temperature of 47° and strong sunshine it disappears quickly, often in less than twenty-four hours.

Wind.—The mean total annual movement of wind in Denver is 62.621 miles. This is less than that of any of the large cities in the United States, save Washington, D. C., which has 58.415 miles. Boston has 101.907; New York, 96.769; Chicago, 136.454; St. Louis, 96.016; San Francisco, 79.206; St. Paul, 63.000. The distribution of the wind is very regular, showing but few and slight variations from the mean. The average velocity is 7.2 miles per hour, which is quite evenly maintained throughout the entire day as registered by hourly periods. This steady presence of the wind even at this moderate velocity gives the impression of greater movement than is had in a region of irregular calm broken by violent winds. There are occasional high winds in Denver, the maximum velocity during any five-minute record in the winter months in the years 1898–99 and 1899–1900 being 53 miles per hour. Such velocities, however, are the exception, and Tables I. and III. show that in a period of six years, the maximum velocity of the wind maintained for one-hour periods, between 8 A.M. and 8 P.M. is only 15.1 miles. The average of these maximum hourly velocities throughout the year is only 12.3 miles.

Together with the velocity must be taken into account the greater lightness of the air at this elevation, a decided factor in the force of the wind.

The dryness of the soil after long periods without rain makes it easily blown by the wind if high. These occasional dust storms are unpleasant but much less frequent than popular accounts would indicate. Moreover, they seem to depend upon some peculiarity of the angle at which the air current strikes the ground, rather than upon the velocity, for every high wind by no means brings a dust storm.

The foregoing discussion with its references to Table I. has dealt with the average climatic conditions as seen over a considerable series of years. Due reference was made to the occurrence of extremes. As it is the weather conditions of single winters which often concern the patient, or the physician in selecting a resort for an invalid, a table [No. III.] has been prepared which will repay a careful study. It gives the details of the weather conditions during the five winter months of two years, one of them (1898–1899) selected for its severity, as it was the worst winter for five years and one of the most trying for an invalid in twenty-five. In comparison, are placed the details for the corresponding months of the year 1899-1900, which was an open, pleasant winter, somewhat above the average. That they are consecutive years adds to the value of the juxtaposition.

The table needs little explanation. The mean temperature in December, 1898, was lowered by one day on which the maximum temperature was 5° and the lowest −20° F. A reference to Table III., columns 4 and 5, will show that the number of days warmer than the mean was double that which was less than the average; in other words, the statistical table was influenced by a single very cold day.

In February, 1899, a similar influence, but to a more marked degree, was exerted by a spell of five very cold days, the rest of the month being very nearly of average temperature. Four of these five days occurred in succession, two had a maximum temperature of 0° F., two of 5° and one of 6° F. The fifth day occurring later in the month had a maximum temperature of only −5°. The untoward influence of these days on the total temperature for the month is emphasized by column 8, where it is seen that excepting these days there were but seven on which the maximum was below freezing. All of these five days, however, were among the fourteen wholly clear days, so that the cold was modified by the diminished humidity and the intense sunshine—factors always to be borne in mind in interpreting Denver weather statistics.

In the data for the following year attention need be called only to the figures in column 8, showing a total of only eight days from November to April on which the temperature was below freezing all day. A study of these tables in conjunction with the means of twenty-eight years in Table I. will emphasize the general facts already given.

In selecting Denver as a resort for an invalid with pulmonary disease the physician should bear in mind that it is a city of considerable size, but surrounded by a wide extent of open, very sparsely populated country. The residence portions of the city stretch out into this open region and the street car system extends to every portion of it. The patient can, therefore, by living in the outlying districts enjoy all the benefits of the climate in pure air and sunshine, and yet be within easy reach of the advantages, material and mental, of a modern progressive city. *Carroll E. Edson.*

DEODORANTS.—The sense of smell is, no doubt, a most important sanitary monitor, although, so far as we know, the offensive volatile products given off from organic material undergoing putrefactive decomposition are not the direct cause of any specific disease. We cannot, therefore, adopt the popular usage which makes disinfectant and deodorant synonymous terms, for, as pointed out in the article on *Disinfectants,* we reserve the former title for those agents which have the power of destroying the infectious properties of infective material.

Deodorants act either (*a*) physically or (*b*) chemically.

(*a*) In the first group—*absorbents*—the most prominent place, from a practical point of view, belongs to *dry earth.* Even the lower animals—dogs and cats—cover their excreta with earth, and from the earliest ages man has depended mainly upon burial in the earth as a means of disposing of organic material of an offensive character, or of that which is likely to become so as a result of putrefactive decomposition. In proof of the efficacy of this method of disposing of putrescible material we need only point to our cemeteries. The "earth system" of disposal of excreta, which has been advocated as a substitute for the "water system," and which some years since was largely practised, especially in England, has led to numerous experiments which have fixed very definitely the neutralizing power of different kinds of earth. In the first rank comes well-dried garden loam; clay, and especially brick clay, is excellent; while sand and gravel are comparatively worthless. Buchanan has shown that loam which has been used once may, after two or three months, be dried in the sun or in an oven and used again, and that this may be repeated over and over again without any perceptible loss of deodorizing power. The quantity required to render inoffensive a single dejection has been fixed by the English authorities —Radcliffe and Buchanan—at one and a half pounds. The same amount is said to be required to neutralize half a pint of urine. Vallin, the highest French authority, believes this amount to be insufficient. He says: "It will be seen that it is much easier to neutralize the 150 gm. of solid matter discharged in twenty-four hours than the 1,200 to 1,800 gm. of urine. The principle of the method is indeed the absence of moisture, the relative dryness of the mixture when first made. We can say at the outset that the feeble point in the earth system is the difficulty of neutralizing the urine. There is no great difficulty in disinfecting and rendering inert the solid material, but the admixture of the urine is a source of difficulty almost insurmountable, because of the enormous amount of earth which this liquid requires." *

Charcoal.—The deodorizing power of charcoal depends upon its capacity for absorbing gases. It also prevents putrefaction by absorbing moisture from organic material over which it is freely spread. When once saturated with moisture, or with the gases given off from putrefying material, the deodorizing power of charcoal is to a great extent lost. The capacity of recently made charcoal for absorbing various gases is shown in the following table:

One volume of charcoal absorbs: 90 volumes of ammonia, 65 volumes of sulphur dioxide, 55 volumes of sulphureted hydrogen, 35 volumes of carbonic-acid gas, 9.42 volumes of carbonic oxide, 9.25 of oxygen.†

(*b*) CHEMICAL DEODORANTS. — *Chlorine.* — Not every disinfectant is a deodorant—*e.g.*, mercuric chloride, and many deodorants are not disinfectants—*e.g.*, ferric sulphate or sodium chloride; but in chlorine we have an agent which is both a disinfectant and a deodorant. The deodorizing power of this gas depends upon its affinity for hydrogen. "It decomposes sulphureted hydrogen, phosphureted hydrogen, ammonia, and volatile organic compounds, by taking possession of their hydrogen, and the hydrochloric acid which is formed also neutralizes a certain quantity of ammonia" (Vallin). Commercial chloride of lime, which is largely used as a deodorant, has the advantage of gradually giving off chlorine. When it is spread upon the surface of decomposing organic matter, it neutralizes the offensive gases as soon as they are formed. This gradual evolution of chlorine is due to the presence of carbonic acid in the atmosphere, which replaces the hypochlorous acid of the hypochlorite of lime—the salt to which "bleaching powder" owes its deodorizing and disinfecting properties. A more abundant and rapid evolution of chlorine may be obtained by pouring a dilute mineral acid upon chloride of lime. For use in the sick-room, a solution of chloride of lime in water—four ounces to the gallon—is to be recommended, both as a deodorant and as a disinfectant; or Labarraque's solution of hypochlorite of soda—*Liquor sodæ chlorinatæ*—may be substituted for the cheaper preparation.

Formaldehyd gas is an excellent deodorant. It combines with various ill-smelling gases, such as hydrogen sulphide, mercaptan, and ammonia, forming compounds that are not offensive to the sense of smell.

Metallic Salts.—Vallin says: "Nearly all the salts which have for base a metal capable of forming with sulphur an insoluble sulphuret, may be used indifferently as disinfectants," *i.e.*, as deodorants. The same author says of these agents that "they are disinfectants in the popular sense of the word; they diminish or cause to disappear bad odors, but their action is limited to the neutralization of ammonia and the decomposition of sulphureted hydrogen and sulphydrate of ammonia." According to Virchow, the first effect of sulphate of iron, when thrown into a latrine, is often to produce, temporarily, an increase in the fœtid odor given off from its contents, on account of the liberation of volatile fat acids—butyric, valerianic, etc., which had previously been in combination with ammonia. The relative power of metallic sulphates to fix ammonia has been given by M. Fermond as follows: Sulphate of copper, 90 to 100; sulphate of zinc,

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* "Traité des Désinfectants, etc.," p. 47.

† Vallin: Op. cit., p. 33.

70 to 80; sulphate of iron, 20 to 25. This is, perhaps, a fair estimate of their relative value as deodorants.

A solution of *chloride of zinc*, known as "Burnett's fluid," has been largely used in England and Germany as a "disinfectant," and in our own country "Platt's chlorides" and other similar preparations have received the indorsement of many leading physicians for "disinfecting" purposes. There can be no doubt as to the value of solutions of zinc chloride as a deodorant and antiseptic, but, as pointed out in the article *Germicides*, the disinfecting power of this salt has been greatly overestimated. A two-per-cent. solution may be used as a deodorant in the sick-room. It has the advantage of being odorless, and of not staining articles of clothing immersed in it, and is quite cheap. Vallin says: "When a spray of a solution of chloride of zinc is thrown into an infected apartment by means of a spray apparatus, all bad odor is neutralized almost immediately, in less than two minutes. This proves that the salt acts less as a caustic or antiseptic than as an absorbent."

Among the useful deodorants, potassium permanganate deserves to be mentioned. It is more especially applicable as a deodorizing wash for foul ulcers, ozæna, fœtid feet, etc., and may be freely used in the proportion of 1 to 1,000. Its effect, however, is quite transient, as it is quickly decomposed by contact with organic matter. For this reason it is not available for deodorizing masses of material in privy vaults, etc.

Caustic lime is a valuable deodorant as well as a cheap and useful antiseptic and germicide. The use of milk of lime for the disinfection of fæces in the sick-room or in latrines is to be recommended, not only because it may be relied upon to destroy the "germs" of cholera, typhoid fever, and other infectious maladies, but also because it neutralizes the bad odors given off from the alvine discharges. *George M. Sternberg.*

DERMATALGIA, or Dermalgia (Greek, δέρμα, skin, and ἄλγος, pain), refers to painful sensation in the skin, other than itching, occurring independently of any recognized disease or alteration of structure; it is known also as neuralgia cutis, and is a rare affection.

The sensations in dermatalgia are variously described as of a raw, burning, stinging, and often of a darting, boring character; the suffering therefrom may vary from moderate discomfort to positive agony. The affected skin has all the appearance of health, and remains normal during the existence of the disease, unless altered by outward applications or injury; but the surface of the affected part may be so exquisitely sensitive that the slightest touch causes great distress, although firm, moderate pressure may relieve the painful sensations. The extent of area affected varies, but generally only a small patch is painful, and that may change position; sometimes there are several tender places, and occasionally the entire surface is the seat of more or less cutaneous pain.

ETIOLOGY.—The disease occurs mainly in middle life, and is more frequent in females than in males, but is by no means confined to hysterical or nervous individuals. The real cause is often extremely difficult to determine; in many cases it is impossible to fix upon any organic or other lesion which could occasion it. Such instances are often spoken of as idiopathic, but it is quite possible that in some of them careful investigation and advanced knowledge may trace an efficient cause in lesions of the brain or spinal cord, as locomotor ataxia, etc.; in certain cases it appears to be reflected from ovarian or uterine disorder. It has been called rheumatism of the skin, and ascribed to the presence of this poison or to that of uric acid; undoubtedly in a certain number of cases it occurs as a pure neuralgia, in connection with anæmia, chlorosis, malaria, etc.

DIAGNOSIS.—This is usually easy to establish, no other condition presenting the features described without skin lesions; when, however, applications to relieve the pain have altered the overlying skin, the diagnosis may be obscured. It is to be remembered that the painful sensations are very superficial, in well-defined areas of the skin itself, and not deep-seated, as in ordinary neuralgia, muscular rheumatism, etc.

TREATMENT.—The general treatment will vary with the case. Anæmic and neurotic subjects must be treated on general principles; the rheumatic or gouty state must be counteracted, if past or present history reveals it; special diseases in females must be remedied, and careful study must be given to trace any condition capable of exciting reflex nerve disorder, such as a loaded colon or rectum, etc. Locally, considerable difficulty may be experienced in obtaining much or permanent benefit. Galvanism affords some relief, and it has been recommended to apply blisters, with morphine, to the part. The surface feels most comfortable when firmly bound with a dressing which prevents all friction, and an ointment of tar and zinc, with belladonna or aconite, spread thickly on lint, will often serve to keep the part free from pain while applied. *L. Duncan Bulkley.*

Beau: Arch. gén. de méd., t. xii., Paris, 1841. Duhring: "Diseases of the Skin," p. 577, Phil., 1882.

DERMATITIS, BLASTOMYCETIC.—In view of the fact that the recognition of this condition is of relatively recent origin, although the literature is now rapidly increasing, a brief review of the results obtained up to the present time will not be out of place here.

This disease is not only important as a newly described affection of the skin, but is also of value in that it was demonstrated for the first time through the investigation of this disease that blastomycetes were pathogenic in man.

On May 30th, 1894, at a meeting of the American Dermatological Society, the writer showed microscopical sections illustrating an hitherto undescribed disease of the skin. The patient had been treated by Dr. Louis A. Duhring, who, from a clinical standpoint, had regarded the case as a typical example of chronic scrofuloderma. The writer's sections, however, proved conclusively that no form of tuberculosis was present, but that the condition represented one of which no account appeared in the literature. The principal histological features were as follows: (*a*) A marked benign hypertrophy of the epidermis; (*b*) the presence, throughout the epidermis and upper part of the corium, of numerous, scattered miliary abscesses, varying in size, some of which communicated with the surface; (*c*) large numbers of plasma cells present chiefly in the corium but also found in the miliary abscesses; and lastly, (*d*) formations in the corium slightly suggestive of tubercles. Many giant cells were also present. Furthermore, the writer discovered in the abscesses and also in the corium numerous doubly contoured, highly refractive bodies, which developed by budding and were identified later as blastomycetes. Usually only three or four of these bodies, but in one instance as many as fifteen, were found in a single abscess. They had a diameter of from 10 to 16 μ, a coarse and finely granulated protoplasm, and were vacuolated. On the addition of liquor potassæ to the sections the organism became more refractive and could more easily be detected. The development of budding could easily be followed out in the sections. The author held that the formation of the abscesses was due to the presence and growth of these organisms—an opinion which he subsequently confirmed by later work. No cultures were obtainable.

As a result of his investigations, Gilchrist applied later the term *blastomycetic dermatitis* to this newly discovered condition.

Six weeks after the exhibition of the above-described sections, A. Buschke, at a meeting of the Greifswald Medical Society, held on July 7th, 1894, referred to a case of skin disease in which he had found coccidial bodies. The whole subject, however, was elucidated by Otto Busse, who recognized the case as one of infection by a saccharomyces. A full report by Busse appears in Virchow's *Archiv* under the title of "Saccharomyces hominis."

The patient, a woman, thirty-one years of age, of a distinctly scrofulous diathesis, presented on the left tibia a swelling, which clinically suggested a gumma or a soft sarcoma. She was very anæmic, and many of her glands were enlarged. Busse found in the tumor a pathogenic yeast-like organism, which he classed as a blastomyces. The disease gradually advanced and roundish ulcerations, with swollen edges, which gradually became confluent, appeared on the face. The same organism was obtained from these ulcers. Other lesions and swellings appeared in various parts of the body, and the patient died of exhaustion. At autopsy nodules were found in the spleen and left lung, abscesses in both kidneys, and a tumor, the size of an egg, in the apex of the right lung. Large numbers of blastomycetes were present in all the lesions. In cultures, they developed as a whitish growth and caused fermentation in grape-sugar bouillon.

By inoculation local abscesses were reproduced in dogs, mice, and rabbits. One rabbit, however, died on the third day, and in the case of white mice, which were killed, the organisms were found in the blood. The blastomycetes measured from 7 to 14 μ in diameter, they were doubly contoured, very refractive, and were found both within and outside of cells.

Busse regarded his case as one of chronic pyæmia, in which there occurred purulent destruction of portions of the skin, knee-joint, kidneys, spleen, and lungs.

A case somewhat similar to Busse's was recorded by M. F. Curtis in France, and he compared the tumor-like growth which occurred in a man to myxomatous tumors. He was able to prove that the lesions were due to a pathogenic blastomyces.

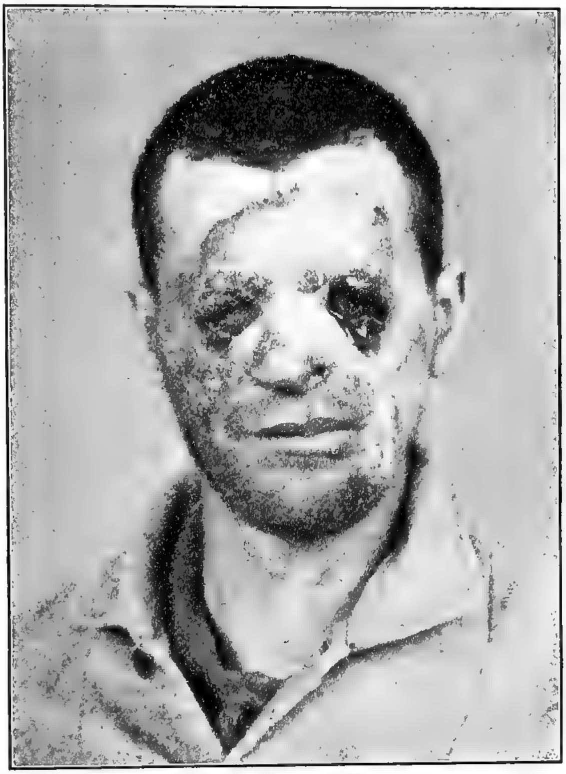

Fig. 1589.—Blastomycetic Dermatitis. (Gilchrist and Stokes.)

The first case of a purely localized blastomycetic dermatitis which was investigated from a cultural and experimental, as well as from a clinical and histological standpoint, is that published by Gilchrist and Stokes (July, 1896, and January, 1898). The patient, a slender but wiry man, thirty-three years of age, had suffered from a peculiar skin disease for over eleven years. The lesion began as a small "pimple," which was situated on the neck behind the left ear, and soon became pustular. It spread forward gradually and finally involved about two-thirds of the face. It always showed a tendency to heal spontaneously, leaving behind at first an hypertrophic and later on an atrophic scar. (The accompanying photograph shows the extent of the lesion and the condition present, when the patient was first seen by the authors.) A second similar lesion appeared one month after the primary invasion, on the back of the right hand. This healed at the end of four years, caustics having been used. Six months after the appearance of the first lesion, the patient noticed a third, on the right side of the scrotum. This gradually increased in size for a year and then healed spontaneously. A fourth lesion appeared on the left thigh, and a fifth on the back of the neck, both being probably due to auto-inoculation. They grew slowly for a year and then healed spontaneously. The lesion on the face, which had been diagnosed as an unusual example of lupus vulgaris, presented the following features: The whole diseased patch had a well-defined margin; the upper border, which extended transversely over the forehead, consisted of a relatively narrow inflammatory zone of red superficial ulceration, covered by a scanty scab. Along the right eyebrow it presented a firm papillomatous appearance. These papillomatous growths could be separated, and sometimes a minute quantity of pus could be squeezed out from between them. These lesions were partially covered by thin scabs. The right border of the diseased patch measured about 2.5 mm. in breadth; it presented, more particularly in its lower portion, a markedly papillomatous character, being dry and scaly. The papillæ were all closely aggregated, the largest being of the size of large pinheads. The lower border presented a superficial ulcerative margin similar to that in the upper border, except at the lower angle on the left side of the face, where it was again markedly papillomatous. The whole area enclosed by this irregular border consisted of one continuous atrophic scar, which was whiter and less dense than the normal skin. The eyelids on both sides were practically destroyed, so that the patient could not cover the eyeballs. Around the left eye the patch presented a raw, red surface, which was moist and bled easily. The tears were continually running over the lesions. The patient said that the disease was not particularly painful. The general health was good; there was no cough and no enlarged glands were noted. There was no history of syphilis or of tuberculosis.

In arriving at the diagnosis, the authors emphasized the fact that each lesion began as a papule, which soon became pustular; later, superficial ulceration or markedly papillomatous lesions were noted. Again, they pointed out that in this case there was an entire absence of the nodules so characteristic of lupus vulgaris, and that papillomatous lesions, although they are sometimes met with in lupus, are never found on the face in such cases.

Sections from the cutaneous lesions showed budding vegetable organisms, somewhat resembling yeast bodies, which were proven to be blastomycetes. The other pathological findings were similar to those described by the writer in his first case, viz.: marked epithelial hypertrophy, numerous miliary abscesses scattered throughout the epidermis and corium, large numbers of plasma cells, and in many sections almost typical tubercles in the corium. (A drawing of a microscopical section and numerous blastomycetes found in sections, as well as a micro-photograph of an epidermal miliary abscess, are represented in Figs. 1590 and 1591.)

The organisms in the tissues were mostly spherical, unicellular bodies, having a diameter of from 10 to 20 μ; they consisted of a doubly contoured membrane enclosing a coarse and finely granular protoplasm with an occasional vacuole. Many budding forms in various stages were found, but no nucleus could be demonstrated and neither mycelium nor hyphæ could be found in the

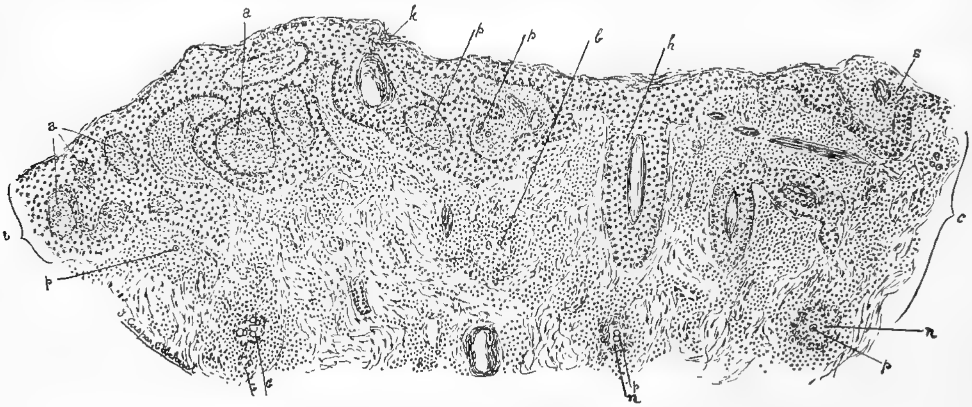

FIG. 1590.—Represents a Microscopic Section of Blastomycetic Dermatitis, showing hypertrophied epidermis (*e*), numerous miliary abscesses (*a*) which contain parasitic organisms (*p*). In the corium (*c*) are pseudo-tubercles (*n*) with giant cells (*G*) and parasites (*p*). (Original.)

tissues. For the most part the parasites were extracellular, although a few were enclosed in giant cells. The organism was obtained, in pure culture, from two parts of the cutaneous lesions, from the pus squeezed out from between the papillomatous areas. The organism grew on all the ordinary media, but especially well on potato and beerwort agar. The cultures showed budding forms and also a fairly profuse mycelium. Older cultures, carried through many generations, consisted chiefly of mycelium. The organisms in the cultures were roundish or ovoid, doubly contoured, refractive bodies, varying from 10 to 20 μ in diameter. Dogs, a horse, a sheep, and guinea-pigs were successfully inoculated, the most striking features being nodules microscopically simulating tumors and pseudo-tubercles in the lungs. The organism was also a pus-producer. This case was identified as a second instance of *blastomycetic dermatitis*, similar to the one reported by the writer in 1894, and the organism was termed *blastomyces dermatitidis* by the authors.

A. Buschke, to whom reference has already been made, has lately done some excellent work upon this subject. He described in minute detail the changes noted in Busse's case, and also reproduced the lesion experimentally upon the patient. On the forehead there was a roundish, sharply indented ulcer, the size of a lentil, which showed a raised edge, only slightly infiltrated, but somewhat undermined, and a livid areola. The base of the ulcer was flat, granular, and covered with a tenacious, reddish-gray secretion. Near by were acne-like nodules, about as large as hemp seeds. Round the hairy part of the neck were four or five small acneiform ulcers. While the patient was under observation the ulcers gradually increased in size, but some of them healed. More ulcers of a similar character appeared upon the face, and a new tumor grew near the elbow-joint, which, however, broke down and formed an ulcer.

The skin disease was partly chronic, partly subacute. The primary lesion resembled an acne infiltration, which broke down at the summit and formed crateriform ulcers with undermined edges and livid areolæ. Buschke found blastomycetes in the skin lesions and also in the patient's blood eight weeks before death. The organisms were also cultivated from the ulcers. In describing the histological features Buschke says that the blastomycetes had entered the skin from without and then set up an inflammation, which had led to a melting away and complete destruction, in the course of which were formed giant cells while beyond them there was formed a marked proliferation of fixed connective-tissue cells. The epidermis was affected secondarily, being in parts hypertrophied and in parts destroyed.

The skin of the patient was inoculated with some of the blastomycetes, and on the fifth day there appeared acne-like nodules; the summits of these soon became necrotic and crateriform ulcers resulted. Blastomycetes alone were found in the secretion, no other bacteria being present. One ulcer arising from an inoculation into the arm healed in ten days.

Since the publication of these four cases fifteen others have been reported, all from this country, and eleven of them occurred in Chicago, the others being widely distributed. Most important contributions have been made to the subject by Hyde, Hektoen, and Montgomery. Here it is only possible to refer briefly to these fifteen cases and to say that all were characterized by a marked similarity as regards the onset of the disease, the clinical appearances, the histologico-pathological features, and the morphology of the organism.

To summarize briefly, then, *blastomycetic dermatitis*, or *blastomycosis*, is a disease of the skin occurring in adults of between thirty and sixty years of age. The lesion begins as a papule or a nodule which usually becomes pustular and then breaks down with the formation of an ulcer. After the ulcer has reached a fair size, it usually presents (in eighteen out of nineteen cases reported) a papillomatous or verruciform appearance, which is especially marked and may be of a fungoid character in very chronic lesions. In many cases, in which the patches were extensive and were situated upon the extremities, the lesions were markedly elevated, in one case forming a cauliflower-like mass an inch in height. The ulcers not infrequently had a foul odor. There was usually a thin mucoid discharge; scabs would form, be thrown off, and replaced by others. The lesions were always somewhat superficial, involving only the skin.

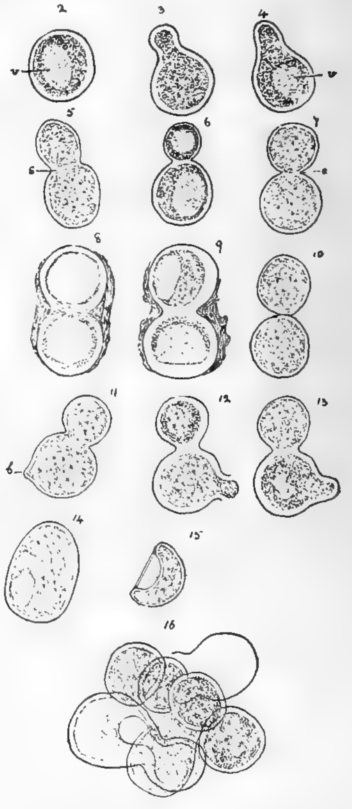

FIG. 1591.—Represents Some of the Individual Blastomycetes Found in Sections like that Shown in Fig. 1590. Nos. 2-16 represent various budding forms; Nos. 8 and 9 show blastomycetes with some form of fibrous coating. (Original.)

The papillæ are about the size of pinheads; they can always be separated, and pus can be squeezed out from between them.

In the very chronic lesions there is always some attempt at spontaneous healing, usually with the formation of atrophic scars. In many cases the ordinary pus organisms are also found in the lesions, but examination of the pus squeezed out from between the papillæ readily shows the presence of the doubly contoured, refractive, budding bodies—the blastomycetes. The organisms are well brought out by the addition of liquor potassæ to the pus. In many cases there is no mixed infection, cultures from the pus giving a pure growth of the organism. Hektoen has shown in cases of mixed infection that if a weak solution of potassium iodide be added to the media a pure culture of the blastomycetes will be obtained, the ordinary pus organisms having been killed.

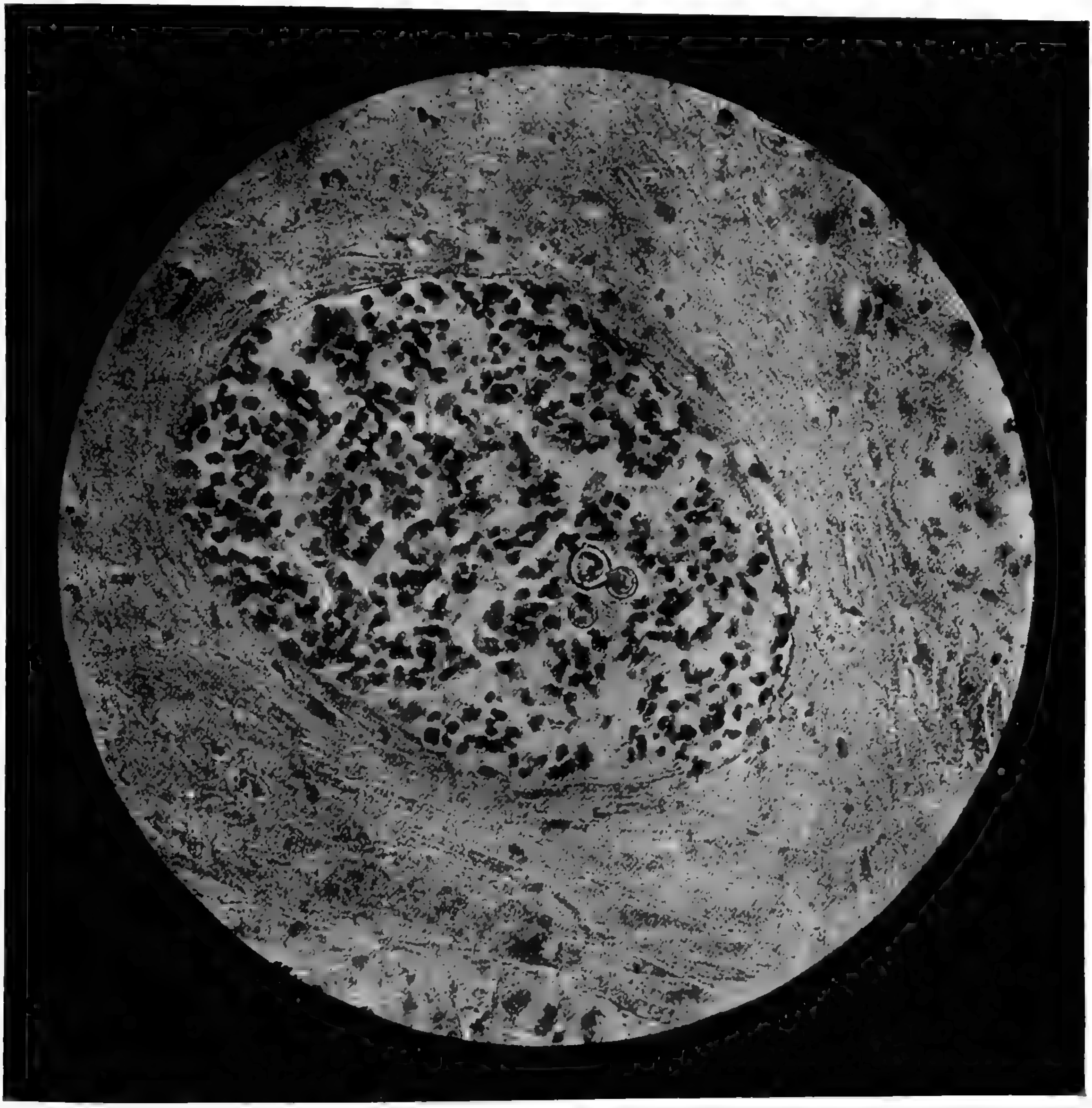

FIG. 1592.—Photo-micrograph from the First Case of Blastomycetic Dermatitis. (Gilchrist.) It shows one of the smaller miliary abscesses contained in the epidermis. Enclosed in the abscess are two blastomycetes, one of which belongs to the large budding variety (seen a little to the right of the centre of the field), whereas the other is a younger detached form which is seen directly below the former. These bodies are similar to those represented in Fig. 1591.

The diseased patch always has a well-defined, raised edge and is slightly infiltrated. The clinical appearance has generally been suggestive of tuberculosis, usually of the papillomatous or verruciform variety. Dyer's case, however, reminded the observer of the yaws. The Gilchrist-Stokes case simulated lupus vulgaris.

The disease is auto-inoculable, and more than one lesion is usually present. The organisms in all the cases except one (Hessler's) were very similar. They averaged about 12 μ in diameter, although occasionally they reached 30 μ in the fresh pus (Buschke). In the sections the organism was doubly contoured, stained fairly well, had a fine or coarsely granulated protoplasm, usually presenting a vacuole. Except in one doubtful instance no nucleus could be detected. The histological features were similar in all the cases. The epidermis presented a marked hypertrophy, sometimes so pronounced that one observer (Coates) termed it epitheliomatous; nevertheless the overgrowth is distinctly benign in character. A special feature of the disease is offered by the numerous miliary abscesses scattered throughout the epidermis, and also through the upper part of the corium. They vary in size from an area equal to that represented by three epidermal cells up to 5 μ in diameter. When the disease is subacute, a few giant cells appear in the corium, as well as numerous plasma cells and miliary abscesses. In more chronic lesions there is a distinct tendency to the formation of pseudo-tubercles. In one out of nineteen cases (Montgomery's) tubercle bacilli were found, but their presence was shown to be due to a secondary infection, from tuberculous sputum, superadded to the blastomycetic invasion. Out of the nineteen recorded cases, only one patient (Busse-Buschke's) died of the disease. In the remainder the lesions were limited to the skin. It is worthy of note that with the exception of two cases (Buschke and Coates) there was no glandular enlargement, not even when the disease had implicated almost the whole surface of the lower extremity (Anthony-Herzog). Moreover, in one of the exceptions (Coates) the enlargement in all probability was not connected with the disease. In some cases, especially in that of Gilchrist and Stokes, there was to be noted a distinct tendency to spontaneous recovery. Another remarkable feature of the disease is the undisturbed condition of the general health, even when the cutaneous lesions were very extensive; and the comparative absence of pain. Thus in the Anthony-Herzog case, where the process had implicated the skin of almost the whole left lower extremity and was of twenty years' duration, the temperature and pulse were practically normal, the thoracic and abdominal organs had remained sound, there was no cachexia, and no urinary changes were discoverable.

So far as may be judged from the cases reported, the distribution of the lesions in cases of blastomycetic dermatitis may affect the face, neck, extremities, and occasionally the scrotum.

So far as *treatment* is concerned, Bevan noted that in his case the internal administration of the iodide of potassium proved to be distinctly curative; while other observers have seen much benefit from the use of this drug. Excision of the smaller lesions and thorough curetting of the larger areas, to be followed by the application of silver nitrate, are the therapeutic measures indicated.

Protozoic Infection.—In this connection it seems suitable to refer to six cases of protozoic infection of the skin and other organs, which have been reported since 1892. Four of these cases were observed in the United States. In all instances the disease proved fatal. Clinically as well as histologically, the lesions are strongly suggestive of those of blastomycetic dermatitis. In the first of the two reported by Rixford and Gilchrist the lesion on the back of the neck of a man, aged forty, was very chronic and presented a papillomatous and verruciform appearance. Pus could be readily squeezed out from between the papillæ. Pathologically, also, there were the typical, marked epithelial hypertrophy, the numerous miliary abscesses in which the organisms were present, and the tuberculous-like formations in the corium, as well as the numerous plasma cells. The organisms were identified as protozoa by Wernicke who described the first case, and by Rixford and Gilchrist. They developed by sporulation, the organism dividing up gradually into about one hundred spores, which were liberated by the bursting of the capsule.

Ophuls obtained a fungus-like growth from his case, and found that, when animals were inoculated with this fungus, the sporulating forms were reproduced. Moreover, when these were obtained fresh from the animals and observed in a hanging drop in bouillon, a growth of mycelium was seen to develop from them. Ophuls' work, then, would go to show that these cases previously described as instances of protozoic dermatitis belong rather to a class more closely allied to blastomycetic dermatitis.

T. Caspar Gilchrist.

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DERMATITIS CALORICA.—DEFINITION.—The changes produced in the skin by its exposure to heat or to cold. These changes vary in grade from a simple, transitory hyperæmia to the absolute destruction of the part, and in many instances are followed by the death of the individual.

SYMPTOMS.—Writers upon this subject have been accustomed to treat of dermatitis calorica under three subdivisions, viz.: dermatitis ambustionis (seu congelationis) erythematosa, bullosa, and escharotica. This is, perhaps, an arbitrary classification, but in the main one well warranted by clinical experience.

Dermatitis Ambustionis.—The first grade of burns (from physical causes) results from the subjection of the skin to a prolonged temperature not exceeding 60° C. or from a momentary exposure to a higher degree of heat. Thus we see that a few hours of a summer sun or a fraction of a second of flames or of steam or of molten metal will bring forth an erythema in the part thus exposed. This is not a transitory condition and we find that pressure upon the skin will not produce its accustomed whiteness but rather a brownish-yellowish hue, and on microscopical examination we note that the superficial vessels are engorged with blood and that some œdema and white-cell extravasation are present.

Subjectively, the skin feels very hot and often extremely painful. Within the next twenty-four to forty-eight hours the surface assumes a rather brownish tint, feels very itchy, and soon begins to be cast off in lamellæ of varying sizes, leaving exposed a slightly pigmented surface which persists for some time.

The treatment for this erythematous dermatitis consists in soothing, cooling, mild applications such as zinc oxide and starch powder (ʒ ss.–℥ i.), mild lead lotions or a wash of carbolic acid ʒ ss., zinc oxide ℥ ss., aq. calcis ℥ viij.

The second grade of dermatitis ambustionis is produced by the subjection of the skin to a heat greater than 60° C.—a condition most commonly seen following contact with very hot water, melted sealing wax, extremely hot sun, or the momentary touch of flames or of hot metal. Vesicles and bullæ form immediately or during the next few hours and the patient experiences great pain.

Pathologically, the roof of the fully developed blister is formed by the stratum corneum or by the whole epidermis, while the papillary layer of the corium constitutes the floor. Confined within these walls we find serum and at times epithelial débris and shreds of fibrin. At times, when the heat has been less intense, the bullous formation is not so complete, and the process somewhat resembles the "cavity formation" and the "ballonization" seen in the pustule of smallpox. Filaments of epithelium remain connecting the separated layers of the skin and a gelatinous material fills the interstices. The changes in the corium are produced according to Unna by chemotaxis resulting from the products of the burn and consist of vaso-dilatation, considerable œdema, and cell extravasation in the upper half of the derma, swollen and flattened papillæ, and degenerated elastic fibres.

The treatment in these cases consists in the opening of the bullæ at their junction with the more normal skin; the application of lead water, of carron oil, or of carbolic acid in olive oil (gr. xv.–℥ viij.); the exclusion of the air and thorough asepsis. When the roofs of the bullæ are broken and raw surfaces are left exposed, mild dusting powders of zinc oxide or of bicarbonate of soda or bland ointments of zinc oxide or of boracic acid are acceptable. If the exposed papillæ show any tendency toward hypertrophy, a daily application of the nitrate of silver stick is of great benefit. When the burns are extensive the continuous water bath of Hebra forms the best means of fulfilling all the above-mentioned indications and spares the patient the tortures of repeated dressings and manipulations. The temperature of the water should be about 31° C. at first, and later it should be raised to 41° or 42° (Kaposi).

The prognosis of burns of the first or of the second degree depends almost entirely upon the extent of the body surface affected. Thus, in an infant a burn of a very small area often produces death, while in an adult a burn covering a half of the body is almost always fatal, and a burn even of a third of the body frequently leads to a similar result.

After an extensive though superficial burn the patient suffers great pain and becomes frequently wild and delirious from his agony. The temperature rises and the urine is suppressed. Even catheterization fails to produce anything but a few drops of liquid, sanguinolent and heavily loaded with albumin. This is the stage of congestion and, if the patient lives, is succeeded usually in from five to six hours by a complete change—that of inflammatory reaction. The pain subsides and in the fatal cases the patient becomes somnolent and soon falls into a stupor accompanied by profound sighing, râles in the lungs, vomiting, clonic contractions and finally opisthotonos, loss of consciousness, and death. This is the second stage and is due to the involvement of the internal organs. Death usually supervenes after the lapse of from eighteen to forty-eight hours, and at the autopsy many lesions are often found, including hemorrhagic erosions of the duodenum or of the stomach, granular degeneration of the vessels, muscles, and parenchymatous organs, hyperæmia of the meninges and nephritis (Kaposi).

In case the patient survives the first shock and is not carried off by the internal processes of the first few days, he is still exposed for several weeks to the dangers of erysipelas, tetanus, pyæmia, exhaustion, pneumonia, or nephritis.

[For a description of burns of the third degree and of burns produced by acids and by caustic alkalis see article on *Burns.*]

Dermatitis Congelationis.—Here, as in dermatitis ambustionis, writers are wont to speak of the effects of the cold upon the skin under three headings, viz.: dermatitis congelationis erythematosa, bullosa, and escharotica. The first or erythematous grade constitutes that condition which is known as pernio or chilblain. This is most frequently observed in children—especially little girls—and to a less extent in anæmic adults, and is always produced by the too sudden warming of the skin after exposure to cold. The parts most susceptible to chilblains are those most exposed to the cold and at the same time those farthest removed from the centre of circulation, *i.e.*, the fingers, toes, ears, and cheeks. The individual enters a warm room or approaches a fire and immediately the part, but a moment previously chilled and blanched and numb from the cold, becomes very red and experiences a tingling sensation. In a healthy person these changes soon give way to normal conditions and no harm has been done, but in the young and anæmic a further pathological process ensues, passive congestion and œdema follow, and as a result the part presents circumscribed reddish areas, often with purplish centres, upon an œdematous base, accompanied by intense tingling, burning, and itching.

As treatment we should paint the lesions with tincture of iodine, camphorated alcohol, iodized glycerin, tincture of myrrh, or a wash of carbolic acid, oxide of zinc, and lime water. Against further attacks we should warn our patient to rub the part with snow or iced water before entering the house, should advise warm coverings for the exposed parts of the body, and should administer iron internally.

As a rule chilblains are a harmless affair, but at times they may slough—the capillaries, previously emptied by the cold, are too greatly distended by the inrush of blood when the heat has been too great and sudden, and an ulcer results. Such an ulcer proves itself slow to heal and demands stimulating treatment internally and externally.

A second variety of dermatitis congelationis of the first grade is the common frostbite which affects most frequently the ears, cheeks, forehead, nose, or chin. This constitutes a deeper process than that of pernio and as a result a solid cake is formed with the skin blanched and cold. After a few hours in a warm atmosphere the skin becomes erythematous, swollen, and very painful. The tenderness and burning persist for a day or two, and the cake gradually disappears followed by desquamation of the epidermis, and in the case of the ears it is often observed that they remain distinctly larger and more susceptible to the cold for several weeks. Treatment consists in friction with snow or with cold water for ten or fifteen minutes and during the subsequent stages the application of cooling washes (zinci oxid. ℥ ss., acid. carbol. ʒ ss., aq. calcis ℥ viij.; or calamin ℥ ss., acid. carbol. ℈i., glycerin. ʒ ij., aquæ ℥ viij.).

The second or bullous grade of dermatitis congelationis is seldom observed alone but usually accompanies the less severe or the more intense forms of frost-bite. When seen the part is anæmic and on thawing vesicles or bullæ with serous, sero-sanguinolent, or hemorrhagic contents may develop. These rarely heal in a few days but more often break down into indolent, circumscribed ulcers.

The third or escharotic degree of frost bite, when encountered in our large Eastern cities, generally follows a drunken sleep during very severe weather. On the other hand cattle-tenders, shepherds, trainmen, soldiers, sailors, and explorers are frequently exposed to intense cold when they are powerless to prevent a part or the whole of the body from being congealed to the hardness of ice. In such conditions the individual at first feels the stimulating effect of the cold, and the exposed parts appear red. As the length of exposure or the degree of cold increases the part becomes painful and later anæmia and some loss of sensation develop. This in time gives way to drowsiness and numbness and an increasing desire for rest and sleep. This is the critical moment, and if the man yields to this craving he runs the greatest possible risk.

A thoroughly frozen part presents always the same characteristic signs. To the touch the skin is intensely hard and cold, insensible to stimuli and of the whiteness of marble. If improperly subjected to the heat of a warm room, the part within a few hours assumes a bluish-purplish hue with possible formation of bullæ, and within from twelve to twenty-four hours gangrene, either moist or dry, follows. When of the moist variety the process may be so deep and so intense that the bones themselves share in the disintegration and death may result from septic absorption even before the line of demarcation has appeared. When it is of the dry type, which is much less common, the usual changes of mummification ensue.

Treatment.—This is a matter of the greatest import and demands the utmost skill on the part of the physician, for upon the slowness with which the blood is allowed to return to the vessels depends the future of the frozen part.

To produce this gradual thawing out, the part should first be rubbed with snow until the icy hardness has in part disappeared, then iced water should be applied and the patient put to bed in a cold room with plenty of blankets to cover all but the affected area, near which ice bags should be placed. The temperature of the room should be very slowly elevated. These precautions are perhaps all that can be taken, and in a few days the extent of the injury will manifest itself by the appearance or not of gangrene. In the mean while, absolute rest in bed and stimulation must be insisted upon, and when once the line of demarcation is clearly marked the surgeon should interfere to avoid as much as possible the dangers of septicæmia. Such measures are frequently highly successful and one is often surprised at the slight loss of substance even after the most solid and extensive freezing.

Charles J. White.

DERMATITIS EPIDEMICA.—Definition.—An acute, contagious dermatitis, attacking preferably the aged, often universal in extent, subject to one or more relapses, accompanied by great prostration, frequently fatal in result, and always followed by desquamation. Pathologically a parakeratosis.

Synonym.—Savill's disease.

Symptoms.—The existence of this disease is denied by many and ignored by others. It was first observed by Savill in the Paddington Infirmary of London in 1891, and from that year until 1895 about five hundred cases were recorded. Since 1895 the disease in epidemic form has sunken into obscurity, but several possible sporadic cases have been observed by Colby and by Fordyce.[1]

The cutaneous outbreak of the disease is preceded by a feeling of local irritation which, within twenty-four hours, is followed by one of three types of initial lesion: first, papular; second, erythematous; or, third and very rarely, circinate. In almost half of the cases these first lesions appear upon the arms, the face, or the scalp, continue for from three to eight days, and are succeeded by a more or less generalized eruption with constant desquamation, which continues with frequent exacerbations and remissions for five or six weeks. This secondary stage assumes a moist type, resembling eczema madidans in sixty-six per cent. of the cases and in the remaining individuals appears as a dry, papular eruption closely simulating pityriasis rubra of Hebra. At this period the patient experiences great burning, itching, and tenderness and intense prostration and anorexia. The third stage of the disease is that of subsidence, when the skin assumes a hard, drawn, brownish appearance, the hair and nails may fall, and the patient is left weak and prostrate. During the epidemic of 1891, 12.8 per cent. of the people afflicted succumbed. The temperature rarely goes above 99° F., and albuminuria is not present except as a slight trace during the height of the disease.

Etiology.—The cause of this affection is still obscure. Savill and Russell, however, independently isolated from the scales and from the blood of the heart a diplococcus which resembled in many ways the Staphylococcus pyogenes albus, but which failed to liquefy gelatin.

Old age and chronic invalidism play an important part as predisposing factors, and it was observed that men were attacked almost twice as frequently as women in the first epidemic.

Pathology.—The microscopical appearances resemble very closely those found in chronic eczema. The rete is hypertrophied, the keratohyalin-bearing cells disappear, the papillæ are swollen, and a few cells surround the superficial vessels of the corium—in other words, a parakeratosis. According to Echeverria,[2] the one important change not observed in eczema lies in the homogeneous degeneration of the more superficial rete nuclei—a process which he has termed peridiaphania.

Diagnosis.—When an acute, practically afebrile, papular or erythemato-papular dermatitis breaks out among the inmates of an institution, shuns the young and attacks the old, continues with one or more relapses for from four to eight weeks, reduces the vital forces almost to a minimum, is accompanied by a continued and almost universal exfoliation of the epidermis, and produces a mortality greater than that of scarlet fever, then we should recall to our minds the peculiar epidemic which was first described by Savill in 1891.[3]

From eczema I think one should differentiate this disease on account of its proneness to attack the aged and on account of the prostration, the epidemicity, the constant exfoliation, and the high death rate accompanying it. Erysipelas, pityriasis rubra, and scarlatina are the other diseases which one must exclude, but I think the reader can readily appreciate the great differences between them and dermatitis epidemica.

Prognosis.—The mortality in the first epidemic was 12.8 per cent. and was much greater in men than in women. In the last epidemic the death rate fell to seven per cent. Thus the disease is certainly one to be dreaded. As a rule, when the disease begins with papules the outlook is better than in those cases in which erythema constitutes the initial stage.

Treatment.—Savill found that daily baths of creolin of twenty minutes' duration rendered the greatest service. Localized lesions were often controlled by applications of collodion, and tar, ichthyol, and oxide of zinc proved of service in allaying the subjective symptoms and in keeping the patient comparatively clean. Internally, sustaining treatment was, of course, necessary in the severer cases.

Charles J. White.

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[1] Monatshefte für praktische Dermatologie, vol. xix., p. 476.

[2] Jour. Cut. and Gen.-Urin. Dis., vol. xvi., p. 73, and vol. xv., p. 141.

[3] British Journal of Dermatology, vol. iv., pp. 35, 69, 105. Jour. Cut. and Gen.-Urin. Dis., vol. xii., pp. 281–329.

DERMATITIS FROM ROENTGEN RAYS.—The immediate, almost universal adoption of Professor Roentgen's discovery in 1896 was soon followed by reports from different countries of a peculiar dermatitis resulting from the action of *x*-rays upon the skin. For the first two or three years the number of recorded cases was ever increasing owing to the more widespread experimentation and to the ignorance of the cause of the resulting inflammation; but now that investigators have learned to avoid too powerful currents and have exercised caution in placing the Crooke's tube at sufficient distance from the skin, the instances of reported accidents are happily distinctly infrequent.

To gain a clearer conception of the alterations induced in living tissues we may divide the resulting inflammations into two classes—those occurring in individuals experimented upon and those observed upon the experimenters themselves. The symptoms which are now to be described are those which occurred in about fifty cases recorded here in Boston, in Baltimore, and in Europe.

First, the accidents to patients. This class constitutes the great majority of cases found in literature and is rich in the variety and in the intensity of its lesions.

Erythema is perhaps the most frequent symptom observed, usually occurring with ill-defined outlines and appearing sometimes within a few hours or at varying intervals up to the sixteenth day.

The condition of dermatitis manifests itself in many ways, and in our list we find the following qualifying adjectives: acute, weeping, suppurating, chronic, and deep. Papular and pustular forms are the rarest, while the vesicular and the bullous (the latter sometimes hemorrhagic) types are much more frequently observed. Often the dermatitis is signalized simply by swelling or by irritation. Very frequently the dermatitis is much severer, and we find the disease assuming a more virulent type, forming eschars; or ulcers, which are often deep and accompanied by intense pain, appear usually in three or four weeks and sometimes require weeks, months, or even one or two years to cicatrize. At times the healing is interrupted by relapses.

Disturbances in the nutrition of the appendages of the skin are also frequent sequelæ, and the application of *x*-rays is not rarely followed by a loss of hair in an area which has been subjected to this peculiar influence. The alopecia is usually observed from the tenth to the thirtieth day and the hair returns slowly, sometimes requiring even months before complete restoration has been effected. Among the rarer complications of the hair noted we find canities.

Changes in the nails are not uncommon, and I have observed such disturbances as pigmentation, persistent pain, and total loss of the nails.

When we examine the later changes which follow the various types of dermatitis we find that exfoliation and desquamation or pigmentation are the commonest, while leucoderma is a rarity, but in all cases we are struck by the peculiarly slow restoration to health.

Such are the objective conditions observed, and referring to the subjective symptoms we must first mention pain, which is characterized in different cases as slight, intense and deep, neuralgic even after a lapse of six months, or lancinating and persistent. After pain, but with far less frequency, writers have described sensations of burning, of irritation, of prickling, of pruritus, of hyperæsthesia, or of partial anæsthesia.

Disturbances of internal organs are not unknown and several instances of nausea, usually supervening in from two to three hours, have been recorded, while vomiting within a few moments and pain, which has persisted for two months, are other examples of involvement of the stomach. Among other internal complications a feeling of oppression about the heart, with or without palpitation, and dyspnœa have been mentioned.

From this short, purely descriptive list we see how many and how varied are the possible lesions resulting from the exposure of the body surface to the *x*-rays, and considering now the possible accidents which may befall the operator we find rather different conditions. Here we see the effect of prolonged and oft-repeated exposure to this strange influence. An experimenter may subject himself for weeks with impunity to the daily action of Roentgen rays, and then, without warning, the hands may become intensely painful or pigmented, the nails may darken or may fall never to return, the hair may disappear, ulcers may form—in a word, all the graver effects which we have noted in patients may come to the experimenter, with these peculiarities, however: the parts affected are almost always the hands, and their restoration to health is almost invariably an exceedingly slow and painful process.

What causes these unfortunate accidents? This is a question which has not yet been definitely answered. Professor Thompson's theory (which is perhaps the most plausible yet given) is that ultra-violet rays are at fault, and he has proved the strength of his argument by the results of experimentation. He allowed *x*-rays to fall upon the skin and found that that area was affected which, by the interposition of blue glass, was subjected to the action of violet rays only. Professor Trowbridge, in a recent article, claims that the *x*-rays are really a light far lower in the scale than the violet rays, thus adding weight to Professor Thompson's theory.

Another idea (that expressed by Tesla) is that the ill-effects of the Roentgen rays are due to the action of ozone and that the greater the heat and the moisture of the skin the greater the resulting damage.

A third theory (also emanating from Tesla) is that during the subjection of the part to the *x*-rays certain minute particles are discharged from the tube and find lodgment in the skin, and this action is especially marked when the tube is of aluminum. Other views have been expressed by foreign writers, among which we may mention that which makes the cathode rays the principal agent, or the ingenious theory that the organic liquids of the body are decomposed and thus produce the grave conditions which we have been studying.

The histology of dermatitis from Roentgen rays has not been investigated thoroughly. Darier gives us the best descriptions, but his work applies chiefly to the milder forms of inflammation. He found that the cells of the stratum corneum were greatly thickened but retained their normal structure; that the stratum granulosum was markedly increased in depth by hyperplasia and by hypertrophy of the cells, which contained many large and numerous eleidin granules; that the cells of the stratum spinosum were also both hypertrophic and hyperplastic, showed mitoses, and contained some migratory cells; and that, with the exception of some extravasated cells, the important changes in the corium were associated with the pilo-sebaceous apparatus where only vestiges of hair follicles appeared, while the hair papillæ, musculi arrectores, and sebaceous glands were quite gone.

Treatment.—Prophylaxis is naturally the first consideration and a safe rule to follow is this: never use a current stronger than from six to eight milliampères and never place the tube nearer to the body surface than from 15 to 20 cm. For the milder accidents, such as erythema, pruritus, vesicles, or bullæ, use a wash of zinc. oxid. ℥ ss., acid. carbol. ʒ ss., aq. calcis ℥ viij.; a dusting powder of zinc. oxid. ʒ ss., amyl. maidis ℥ i.; and a paste of zinc. oxid. ʒ ss., amyl. maidis and vaselin. āā ℥ ss. For the cases in which ulcerations have occurred, try at first a wash of hydrarg. chlorid. mit. ʒ ss., aq. calcis ℥ viij. or one of ferri et potass. tartrat. ʒ i., alcohol ℥ i., aquæ ℥ vij., the zinc oxide paste above mentioned, and a powder of nosophen or of ferri subcarb., amyl. maidis, āā ʒ ij. Where there is a broken surface associated with intense pain an ointment containing from five per cent. to ten per cent. of orthoform has proved of benefit. When all remedies have apparently failed to cicatrize a stubborn ulcer we may resort to skin-grafting, to the use of static electrical baths, and to the application of oxygen to the part.

Charles J. White.

DERMATITIS GANGRÆNOSA INFANTUM. See *Varicella Gangrænosa.*

DERMATITIS HERPETIFORMIS.—(Synonyms: Dermatitis multiformis, Dermatite polymorphe douloureuse [Brocq], Pemphigus pruriginosus [Cazenave], Hydroa bulleux [Bazin]; Herpes gestationis [Milton], Hydroa herpetiforme [Tilbury Fox], etc.)

Definition.—A chronic, relapsing dermatitis, marked by successive outbreaks of erythema, papules, vesicles, or bullæ, accompanied by itching and tending to disappear in the course of months.

Symptoms.—The cutaneous eruptions of dermatitis herpetiformis are usually preceded by a feeling of malaise or are ushered in by chills or by fever. The patient soon notices that his body—especially the arms—is mottled with brilliant macules which in a few days develop into irregular, flattened, scarlet papules which in their turn are capped by vesicles. In the course of a few days these vesicles coalesce and become bullæ or remain isolated and soon become ruptured or are infected and become pustules. Associated with these changes, which may require a week for their completion, the patient experiences a feeling of intense pruritus. Each of these lesions may not develop synchronously with its neighbor, and therefore the same individual may present upon his body macules, papules, vesicles, pustules, or bullæ, and, on account of his itching, scratch marks and crusts and later in the disease pigmentation. It is this great variety of lesions occurring at any given moment which has suggested the title of dermatitis multiformis.

Once arrived at its full development the disease may gradually improve and in a few weeks the skin may be restored to its original state, but far more frequently the patient will experience repeated attacks, each one preceded by the usual prodromes of malaise or of fever and attended by severe itching. As a rule the disease lasts for two or three months, but many cases are observed which persist even for many years.

We have thus far described the so-called typical example, but let us now consider the anomalous case, which, curiously enough, is more commonly seen. Instead of malaise or chills or fever we may have pain, burning, itching, insomnia, dyspnœa, or intense hyperæsthesia as precursors of the disease. From an objective point of view we may note that the disease omits the macular and papular stages and begins with an attack of vesicles with or without a halo of erythema. These vesicles are usually small and flat with irregular outlines and are often grouped, thus suggesting herpes—the condition which Duhring considered most characteristic of the disease. Again, pustules may form as such without passing through the earlier stages, but many authors deny that such a condition is possible and assert that pustules are always secondary to vesicles and are the products of infection. Again, bullæ may be the first outward manifestation of the process, may appear on the mucous membranes, and may reach the size of a twenty-five-cent piece. They are usually unilocular and their serum soon becomes turbid. Again, the disease may assume an urticarial type and appear in circinate forms with or without secondary vesicles. Frequently, as the result of scratching, furuncles, lymphangitis, and adenitis are produced; and lastly, as rarities, we may meet with keratoses of the palms and soles or papillomatous growths about the articular folds of the body. It is doubtful, however, whether these last-named characteristics exist independently, for in the former condition we can never positively exclude the effects of arsenic which has usually been administered, and in the latter we cannot deny that irritation and infection have not produced the hypertrophy.

When a patient has endured the disease for any length of time his body presents a striking appearance. In the severe cases there is hardly a spot upon the whole surface which appears normal. Interspersed among innumerable small pigmented macules appear the acute lesions of the disease, such as papules, vesicles, or bullæ in various stages of development or of retrogression. The patient is apt to be emaciated from loss of sleep, but in other respects the records of the case will show no important deviations from health. Possibly a mild diarrhœa or a slight evening rise of temperature may have existed, but nothing more serious, except in the very severe cases, in which we may have "dyspnœa, endocarditis, bronchitis, angina, pulmonary congestion, or hæmoptysis" (Brocq) to contend with.

Pathology.—The histological changes in dermatitis herpetiformis are mostly those of diapedesis, most accentuated in or near the papillæ. In this region of the corium the vessels are dilated, œdema is present, and the swollen meshes of the connective tissue contain lymphocytes, eosinophiles, and, later, polynuclear leucocytes. The deeper layers of the corium are normal, while in the rete we find a few eosinophiles and some hyperplasia (acanthosis). As the disease progresses and approaches the vesicular or bullous stage, the rete cells are vacuolated, a few polynuclear leucocytes appear, and œdema becomes more marked. In the papillæ similar changes are occurring until finally the two layers separate and the epidermis is raised, forming a liquid chamber containing fibrin, coagulated albumin, and many eosinophiles.

The blood changes are extremely interesting and have been studied especially by Leredde, who claims more than other investigators are willing to admit. Leredde asserts that eosinophilia is constantly present and increases very perceptibly with the appearance of a fresh outbreak of vesicles or bullæ. According to his figures the percentage of eosinophilous cells is generally from eight to fifteen and may run up to from twenty to forty, while the polynuclear leucocytes are reduced to forty or fifty per cent. In a bulla occurring in one of Dr. White's cases in Boston, Cabot found eosinophiles present to the amount of ninety per cent. From the results of these studies Leredde wishes to call this disease hématodermite.

Diagnosis.—Before asserting positively that a patient is afflicted with dermatitis herpetiformis, one must exclude the possibility of erythema multiforme, eczema, pemphigus, dermatitis medicamentosa, impetigo herpetiformis, and possibly urticaria bullosa and hydroa æstivale. Such a differential diagnosis is by no means always simple, and in many cases it is only after careful questioning and a supervision of the case for a sufficient period of time that the physician can be sure that his diagnosis of dermatitis herpetiformis is correct.

Space does not permit, in this résumé of the subject, to go minutely into the details of all these possibly conflicting diseases, but let us remember that if we are consulted by a person who has a dermatitis which presents a multiformity of lesions, among which vesicles and bullæ are especially prominent, and which are accompanied by great pruritus, we must surely consider it probable that we are dealing with a dermatitis herpetiformis. And if the disease has lasted many weeks and is marked by successive outbreaks of grouped vesicles preceded by fever and malaise and followed by intense itching and no other bodily disturbance, then we may feel almost positive of the correctness of our diagnosis.

Treatment.—At all periods of the disease we must try to alleviate the distressing pruritus, and in all probability one of the following prescriptions will prove of benefit: ℞ Zinc. oxid. ℥ ss., acid. carbol. ʒ ss., aq. calcis ℥ viij.; ℞ Pulv. calamin. ℥ ss., acid. carbol. ʒ ss., glycerin. ʒ ij., aquæ ℥ viij.; or ℞ Zinc. oxid. ʒ ss., sulph. præcip. ʒ ss., lanolin. ℥ i.; and internally we may try: ℞ Potass. acetat. ℥ i., aquæ ℥ viij. S. Tablespoonful in water t.i.d., or ℞ Phenacetin, gr. x. t.i.d. We must advise a mild, nourishing diet and forbid all exciting foods and drinks.

When the disease has established itself, internal administration of arsenic, quinine, ergotin, atropine, iron, or strychnine and a mild, supporting diet and rest in bed often afford relief.

Prognosis.—In almost all cases we can assure our patient of an ultimate recovery; but he must prepare himself for many vexatious setbacks and delays. If, however, the patient is old and feeble and the disease has assumed the distinctly chronic phase we must not be too hopeful, for inanition from the effects of the disease and from loss of sleep or intercurrent diseases may carry him off despite our most careful treatment.

Charles J. White.

DERMATITIS, MALIGNANT PAPILLARY; PAGET'S DISEASE.—Definition.—A very chronic, finely papular dermatitis, usually of the female nipple, associated with oozing and crust formation and in course of years degenerating into carcinoma.

Symptoms.—In 1874 Sir James Paget published a description of fifteen cases of the peculiar affection which has since borne his name. The disease may begin with an unusual plugging, with horny concretions, of the follicular openings about the nipple, or it may first appear as a mildly desquamating dermatitis of the areola. This condition is soon followed by a slight oozing with consequent adherent crusting, and this appearance, in turn, yields to exulceration. Thus the disease is fully established, and with a gradually increasing circumference it may remain in this stage for years. It is usually in this stage that the physician first sees his patient and on examination will note the following characteristics: he will find a dermatitis, usually of one breast, very rarely of both, varying in size from the area of the areola to one involving the whole breast with the nipple as its centre; he will find the lesion round or elliptical in shape, with a delicately raised, finely serpiginous border about which may be seen minute vascular twigs; he will be peculiarly struck with the very brilliant redness of the part, which appears as a raw surface covered with minute papules, some of which are tipped with newly formed epithelium, and producing a "copious, clear, yellow, viscid exudation" which dries and forms crusts; and finally he will recognize, on grasping the lesion between his fingers, a feeling of delicate resistance, as though a piece of cardboard or a thin layer of metal were embedded in the skin.

Connected with these outward signs the patient will complain of pain, which may be neuralgic or lancinating, and when the disease is well advanced pruritus will develop and frequently become annoying, leading to scratching and consequent fissuring of the skin.

The disease will thus progress slowly with gradual destruction and retraction of the nipple, and in the end, which may not be for twenty years, will degenerate into carcinoma, which always begins in the region of the nipple and may remain superficial or may involve the whole organ and surrounding tissues and lead to metastasis. These are the symptoms of Paget's disease, which, as a rule, attacks the female nipple, but it has been observed by Crocker upon the scrotum and by Pick upon the glans penis.

Etiology.—Age plays an important rôle, and, although an example of the disease has been observed in a patient of twenty-eight, the vast majority of cases occur between the ages of forty and sixty years. Sex also proves a deciding factor, as but few cases thus far have been observed in men. As to the actual determining cause of this disease, the pathologists are at present uncertain. In 1889–90, when Wickham and Darier published their excellent monograph (which to-day remains the best we have upon this subject), the theory was accepted that coccidia or psorosperms—a subdivision of the sporozoa—were the undoubted cause. To-day, we must hold our decision in abeyance, awaiting the final settlement of the question as to whether these peculiar bodies are really living parasites or merely strangely degenerated epithelial cells.

Pathology.—The microscopical study of Paget's disease is extremely interesting. Darier and Wickham divide the lesions into three stages:—first, that of hypertrophy; second, that of atrophy; and third, that of cancer.

First Stage.—Here the horny layer is thin and composed of delicate lamellæ, the granular layer is slightly increased in thickness, and the mucous layer appears to be two or three times thicker than normal. This layer contains at the same time, in varying abundance, the peculiar bodies which differ in protoplasm, in shape, and in size from normal epithelium, and are enveloped in a double, highly refractile, hyaline membrane. At times the interpapillary down-growths are composed entirely of these bodies. The derma presents two distinct layers, the upper of which is formed of dense, parallel, straight fibres, which receive faintly the coloring reagents and contain in their interstices fusiform or flattened connective-tissue cells. Unna holds an entirely different conception of this layer and claims that it is all a pure plasmoma. From this region all elastic fibres have disappeared, but the blood and lymph vessels persist as straight, vertical, enlarged tubes, and much inflammation is visible about the sebaceous glands. The lower layer of the derma, including the sweat glands, remains normal in all respects.

The Second Stage.—This is in reality a condition of atrophy, and we find the horny and granular layers completely absent in places and the rete Malphighi either also gone or reduced to two to three layers of cells, which in turn are almost entirely composed of the peculiar psorosperm (?) bodies and extravasated leucocytes. The derma presents the same characteristics as in the first stage.

The Third Stage.—A detailed description of this stage would carry us beyond our limits, but let us only say that the cancer usually makes its first appearance in the surface epithelium, where it assumes the alveolar type, or it may begin in the lactiferous ducts or at times in the breast tissue itself.

It is interesting to note that the so-called coccidia can be demonstrated by scraping gently the surface of the lesion and examining the scales under the microscope after they have been soaked for a few moments in tincture of iodine or in bichromate of potash or in liquor potassæ.

Diagnosis.—There is only one disease to be excluded before making a diagnosis of malignant papillary dermatitis and that is eczema. Eczema of the nipple appears during the child-bearing period, while Paget's disease is most unusual before the age of forty years. In eczema we find a soft area having an ill-defined border and characterized by the presence of vesicles, pustules, œdema, and pruritus, and when the disease has become chronic we find frequent improvements or exacerbations. In Paget's disease none of these characteristics is present and in their stead we see an area that is frequently painful to the touch, is brilliantly red in color, has a granulating surface, yields but rarely to medical treatment, and constantly increases in size through years and years.

Treatment.—Authorities differ in their views in regard to the treatment of Paget's disease. The English believe in mild applications, and, if no improvement ensues after sufficient trial, they advocate thorough extirpation as soon as the diagnosis has been confirmed by the microscope.

The French, on the other hand, try first their mild measures and resort to the knife only when more active means—such as applications of from five- to ten-per-cent. pyrogallic acid, or ten-per-cent. iodoform, or thirty-three-per-cent. chloride of zinc—have failed.

Prognosis.—So far as the life of the individual is concerned the future is comparatively hopeful, for ample warning is given the surgeon to reach a correct diagnosis and to remove the new growth before metastases have been formed. As to the future of the original disease, it is only proper to tell the patient that if she neglects the new tissue change she must inevitably expect to suffer for her rashness.

Charles J. White.

DERMATITIS MEDICAMENTOSA.—By this term—in the strict sense of the word—is meant a congestion or inflammation of the skin resulting from the action of drugs taken into the system through the digestive tract. Those eruptions which result from the direct application of drugs to the cutaneous system constitute the condition known as dermatitis venenata, and these will be discussed in a later article. A true drug eruption is not of common occurrence, and when it is encountered it is usually the result of some idiosyncrasy. It may be due to an acute poisoning following an overdose of the given drug, or it may be the natural sequence of a cumulative action of the drug due to a retarded action of the emunctories. In the idiosyncratic cases the eruption may follow a single small dose of the drug, which may then be regarded as a poison to the individual in question.

As to the nature of the eruption, it varies greatly. By far the most common form is a more or less diffuse erythema or blush, while scarlatinoid and urticarial rashes are by no means infrequent. More rarely will purpuric spots be noted, or bullæ and nodular eruptions, while again pustular dermatitis characterized by true, more or less minute abscess formations, will result from the action of certain drugs, as quinine and potassium iodide. The individual lesion in these cases does not differ materially or even at all from the simple form of the eruption, and is recognized as resulting from the drug action only because of its appearance after the administration of the drug, or because it is present in greater numbers than in the uncomplicated condition or in unusual locations. The theories as to the development of the eruption vary. According to some, they follow a marked vaso-motor action, as in the cases of the erythematous, urticarial, and scarlatinoid rashes. In these cases there must ensue a paralysis of the vaso-motor system either locally or affecting the entire system, when the spinal vaso-motor centre is involved. According to Morrow, the eruption may result from some irritation of the sensory nerves of the gastro-intestinal mucosa. Again, the trophic centres regulating the nutrition of the skin may be the parts primarily affected; but whatever the etiology a peculiar idiosyncrasy undoubtedly exists in many cases.

Proceeding now to a study of the various forms of drug eruption that have been noted, we find the following given in their alphabetic order:

Abscess or Pustular Dermatitis.—Quinine has been found to give rise to single or multiple abscess formation in certain instances, as recorded by Morrow, Neumann, Schuppert, and others.

Bullæ.—A number of drugs will produce a bullous eruption. Thus, very rarely, bromine may so act, as in a case reported by Wigglesworth, the eruption appearing on the trunk and the blebs varying in size from a split pea to the finger tip. Other drugs so acting are aconite (Panas), quinine, chloral, copaiba (Hardy), morphine (Kirn), phosphoric acid (Hasse), cannabis indica (Hyde), and iodine (Fox and Hyde).

Cyanosis.—Blueness of the skin has been frequently noted after the administration of large doses of the coal-tar products, notably antifebrin or compounds of that body, such as monobrom-acetanilid. The skin is anæmic and slaty colored in most of the instances. Examination of the blood in these cases shows it to be of a dark blue color.

Desquamation.—Marked and persistent desquamation has been recorded by Koebner after the use of quinine, and this occurred subsequently to the appearance of an erythematous rash. Moderate desquamation usually follows the erythema produced by quinine ingestion.

Ecthyma.—Bromine has rarely given rise to an ecthymatoid eruption, as recorded by Van Harlingen and Voisin.

Eczema.—Various drugs may produce an eczematous rash, notably anacardium, chrysarobin, borax (Féré and Larrey), potassium bicarbonate, iodoform (Neisser), and rarely bromine (Voisin).

Erythema.—A great variety of drugs have, when ingested in large quantities, given rise to a more or less diffuse erythema. Among these may be mentioned acidum benzoicum, acidum boricum, anacardium, antipyrin, arsenic, acidum salicylicum, belladonna, bromine, chloral hydrate, chrysarobin, copaiba, cubebs, iodoform, morphine, potassium chlorate, stramonium, strychnine, sulphonal, tar, tartarus boraxatus, terebene, tuberculin, and turpentine.

Furuncle.—Small boils or furuncles have been noted after the ingestion of certain drugs, as arsenic, bromine, quinine, and potassium iodide. It is a common manifestation of iodism.

Gangrene.—This rare trophic skin disturbance has been observed after the use of arsenic, ergot, potassium iodide, and quinine (Schuppert).

Herpes.—Salicylic acid may produce an herpetic eruption.

Pigmentation.—A darkening or discoloration of the skin may follow the use of arsenic, acidum picricum, and the silver salts (argyria).

Pityriasis.—A form of pityriasis rubra has occurred from the use of potassium bichromate.

Psoriasis.—Borax and potassium bichromate in individuals so predisposed may produce a psoriatic eruption.

Purpura.—A number of drugs have caused a purpuric eruption, notably salicylic acid, chloral hydrate, chloroform (by inhalation), the iodides, quinine, and sulphonal.

Pustules.—Aconite, arsenic, salicylic acid, bromine, chloral, and iodine have given rise to pustular formations.

Urticaria.—Anacardium, bromine, copaiba, iodine, resin, quinine, salol, and santonin may produce an eruption of urticarial wheals.

Vesiculæ.—Vesiculæ have been noted after the ingestion of many drugs, mainly salicylic acid, aconite, cannabis indica, chloral, copaiba, iodine, morphine, oleum morrhuæ, quinine, and turpentine.

Zoster.—Arsenic may produce an eruption of zoster.

Of all the drugs that may give rise to lesions such as are recorded in the foregoing list, there are but two, the bromides and the iodides, which are common and persistent. These are so well known that a more detailed description at this place will not be necessary. The exanthematous rashes produced by many drugs are purely vaso-motor in origin. All of the various symptoms are prone to occur in clearly defined groups, without any features that would differentiate them from the eruptions resulting from other causes. Their course may be slightly atypical in that there may be an absence of some of the symptoms usually associated with the eruption, or the presence of a symptom not generally noted, but, as a rule, the course and duration conform to the ordinary, and the diagnosis must be made from the history of the case, from the disappearance of the eruption on the withdrawal of the drug, and from its prompt reappearance when the treatment is resumed. The subjective symptoms vary with the eruption. Frequently there is a sensation of burning, tingling, or itching, this often being associated with the peculiar physiological manifestations of the drug. Often no symptoms are present beyond the appearance of the characteristic eruption.

The treatment of drug eruptions consists in the immediate withdrawal of the drug and in the application of some healing substance, as the glycerite of tannin (1 to 3), boric-acid ointment, ichthyol ointment (in lanolin or antiphlogistin), or simple cold cream or vaseline. Antipruritics, as carbolic-acid solution, may give relief, and alkaline diuretics are often useful. In certain cases in which an eruption is feared from the use of a given drug, it is possible so to combine the remedy with other substances as to ward off the unfavorable manifestation. Thus, the mineral acids may be given to prevent the rash which follows the use of pyrogallol and chrysarobin. Liquor potassii arsenitis in small doses, given with potassium iodide or potassium bromide, appears to modify acneiform eruptions. The number of drugs capable of producing a dermatitis venenata is, figuratively speaking, legion, and it is manifestly impossible in an article of this size to enumerate them all. *Emmanuel J. Stout.*

DERMATITIS PAPILLARIS CAPILLITII.—(Synonyms: Dermatitis Papillomatosa Capillitii, Acne-Keloid or Acne Chéloidienne [Bazin]; Sycosis Capillitii [Rayer]; Sycosis Frambœsia [Hebra]; Mycosis Frambœsioides or Pian Ruboïde [Alibert].)

Kaposi was the first to describe this affection under the above title. It is regarded as a very rare disease, although the author has had the opportunity of observing five cases in five years, three of which occurred in negroes and two in white individuals. Different opinions exist as to its exact character. Thus Brocq regards it as a form of folliculitis decalvans; Hebra calls it sycosis frambœsiformis; Bazin has given it the name acne-keloid; and Alibert has described the process as pian ruboïde. Kaposi looks upon the disease as being entirely independent of syphilis and not originating in the follicles, and he regards it as an idiopathic inflammatory condition, which usually begins on the back of the neck at the lower hairy margin and extends upward toward the vertex.

Symptoms.—The disease first manifests itself in the form of papules, the size of a pin's head, which are isolated at first, but soon become closely crowded and form cicatricial, keloidal, pale or red plaques which are very firm. Later, exceedingly vascular, papillomatous vegetations, consisting of granulation tissue, develop in the occipital region. These growths project from 2 to 3 cm. above the level of the skin, bleed easily, are covered with crusts, and exude an evil smelling secretion. At times abscess formation and destruction of tissue occur. After the process has continued for years the growths are replaced by cicatricial formation, keloidal in character, and pronounced atrophy of the hair follicles results. Bald patches are visible here and there and the hairs are arranged in tufts on the cicatricial tissue—conditions which are characteristic of the affection. The hairs are removed with difficulty; they are brittle, twisted, and tortuous. When the nodules are incised with a scalpel, distinct creaking can be detected and the cut surface shows numerous bleeding points. Small pustules are observed here and there. Slight tenderness and decided pain at times may be experienced by the patient; these symptoms, however, may be lacking. The disease pursues a very slow course, but continues to progress.

Etiology.—The cause of the affection is unknown. It is said to appear at any time of life and in either sex; the cases observed by the author were all in males, ranging from twenty-two to thirty years of age, three of them being negroes. The situation of the lesions has led some to attribute the occurrence of the disease to irritation from collar or shirt buttons.

Pathology.—According to Kaposi the affection consists in a chronic inflammation of the corium, in consequence of which a free production of connective tissue, of blood-vessels, and of papillary outgrowths from the skin ensues. The pressure of the new connective tissue causes destruction of the sudoriparous and sebaceous glands and atrophy of the hair follicles.

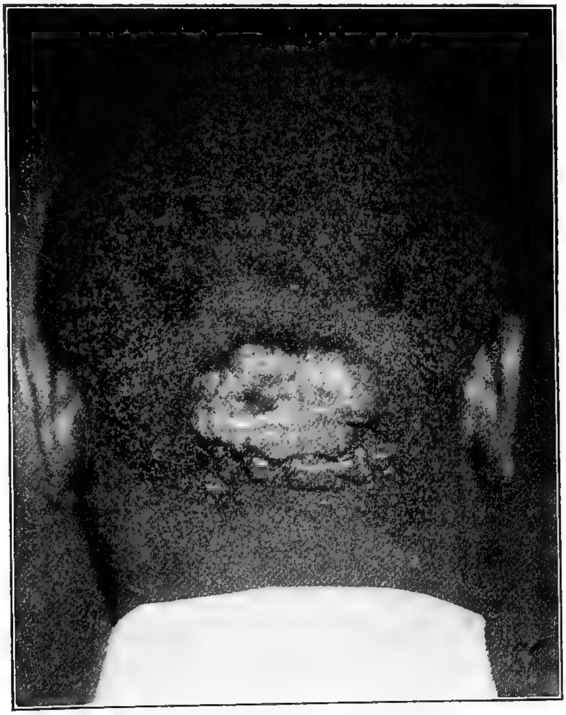

Fig. 1593.—Dermatitis Papillaris Capillitii in a Negro. (Case of Dr. H. W. Stelwagon.)

Diagnosis.—The location of the disease upon the back of the neck, the peculiar hardness of the growths, the presence of hair, arranged in tufts, on sclerosed tissue, are characteristic of the affection. In sycosis the two latter features are not present, and the pustules are penetrated through their centres by a hair; in acne-keloid, however, this is not the case. Verrucæ and papillomata are not so firm to the touch, they pursue a different course, and the keloidal condition is absent.

Prognosis.—The general health does not appear to be influenced by the affection; it is quite rebellious to treatment and prone to recur after removal. The course of the disease is steadily progressive and shows no tendency to spontaneous recovery.

Treatment.—This is quite unsatisfactory. Removal with the knife, curetting, application of caustics or the actual cautery, have all been tried. In two cases, which the author had an opportunity to observe, the disease returned after thorough excision. Kaposi speaks of emplastrum hydrargyri being effective. He advises removal of the papillary and keloidal growths with scissors and knife. The resulting hemorrhage is controlled with cotton tampons and the additional application of silver nitrate, 1 to 1, or the Paquelin cautery. Thorough cauterization of the base is imperative after removal. The galvano-cautery has been employed by Hebra, Jr., who entertains a high opinion of this method of removing the growth.

The author is indebted to Dr. H. W. Stelwagon for the accompanying illustration. *Emmanuel J. Stout.*

DERMATITIS REPENS.—Definition.—A dermatitis, acute in type, chronic in character, arising from a wound of the hands or of the feet, spreading always peripherally and dependent probably upon some nerve disturbance.

Symptoms.—Dermatitis repens was first described by Radcliffe Crocker[*] in 1888, and in 1896 and in 1897 by Stowers[*] and by Frèche[†] respectively, who described conditions which correspond in many ways with Crocker's original cases. Since then no writer, to my knowledge, has added to this small list of cases.

The origin of the disease can almost always be traced to a wound of an extremity—usually the hand. The patient notices that the injury is slow in healing and gradually realizes that the disease is increasing in extent. This slow but persistent spread has been watched from its original seat at the finger tip over the entire hand, up the arm, across the shoulder and down the opposite arm. The original lesion is a vesicle or a bulla which ruptures, leaving a moist, intensely red, exposed base. By an indefinite repetition of this primary process the disease spreads, producing a sodden, raised, and undermined border which leaves in its wake either a moist, oozing, erythematous area or a dry, glistening, pinkish skin devoid of the horny layer.

The progress of the disease is very slow and the rate of spread varies from one-eighth to one-fourth inch a week. The longest duration of the entire process yet recorded is eight months. The health of the patient is not affected and the temperature remains normal. Subjective symptoms are practically wanting.

Etiology.—Our knowledge of the origin and the subsequent progress of this rare condition is at present merely one of conjecture and depends upon no bacteriological or histological investigations. Crocker argues from its manner of growth by peripheral extension only that it is bacterial in origin, and from its chronicity and from its resistance even to the strongest bactericidal chemicals that some disturbance of nutrition favors the progress of the disease.

Pathology.—Unfortunately, dermatology has received thus far no data upon the microscopical conditions associated with this affection.

Diagnosis.—Eczema madidans, a late syphilide, and ringworm are the three conditions to be excluded before committing oneself to the unusual diagnosis of dermatitis repens. The probability of the first disease could be eliminated by the chronic and obstinate continuance of the process, by peripheral extension, by the absence of subjective symptoms, and by the healthy influence of such powerful agents as sulphate of copper, permanganate of potassium, etc. A dry, scaling syphilide could be ruled out probably by therapeutic tests, by the superficial character of the lesion, and by the possibilities of wide-spread extension exhibited by the disease. And lastly, all possibility of the affection being caused by a trichophyton fungus could be dispelled by the aid of the microscope.

Treatment.—The rational treatment suggested by clinical observation consists in the local application of drugs sufficiently powerful to destroy the possible active agent at work in the moist periphery of the disease, and therefore such chemicals as nitrate of silver, sulphate of copper, lactate of lead, and permanganate of potassium were employed in Crocker's cases after the raised, surrounding border had been removed.

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[*] "Diseases of the Skin," 2d edition, p. 180.

[*] Stowers: Brit. Journ. Dermatology, vol. viii., p. 1.

[†] Frèche: Annales de Dermatologie et de Syphiligraphie, vol. viii., p. 491.

PROGNOSIS.—The checking of the disease and restoration to health are at times very slow, but in the end the patient can well expect a complete recovery and need have no fear of subsequent relapse.

Charles J. White.

DERMATITIS VENENATA.—Under this title are embraced the various dermatitides resulting from irritation of toxic agents belonging to the mineral, vegetable, and animal kingdoms. The dermatitis assumes various appearances; it may be erythematous, urticarial, papular, vesicular, pustular, bullous, or gangrenous in character. Among mineral substances the aniline dyes, which are used largely in the dyeing of wearing apparel, such as drawers, flannel shirts, colored underskirts, and the linings in hats and shoes, are very prone to produce an eczematous, pruritic eruption of the parts with which they come in contact. Usually the inflammation is papular; it may, however, be of a vesicular or pustular type, and excoriations and ulcerations may result. The disease is usually confined to a limited area, but it may extend to some distance beyond the parts first involved; it is attributed to the arsenic in the dye. Paper collars and cuffs are also at times a source of mischief to the skin owing to the sizing containing arsenic. Morrow has observed dermatitides of an eczematous character on the face which he attributes to the wearing of mourning veils of crêpe.

Potassium bichromate, which is employed in certain trades, is apt to produce, in those who handle it and are employed in its manufacture, eruptions of various character. B. W. Richardson reports cases of poisoning with potassium bichromate resembling pityriasis rubra; in one case acute eczema of the arms and an eruption involving the palms, resembling psoriasis, occurred; the other cases bore a resemblance to psoriasis, eczema, or pityriasis. According to Richardson the nasal mucous membranes may ulcerate and perforation of the septum may result. He states that the inflammation at times becomes very marked and destructive and is accompanied by suppuration and ulceration, which may extend to the bone.

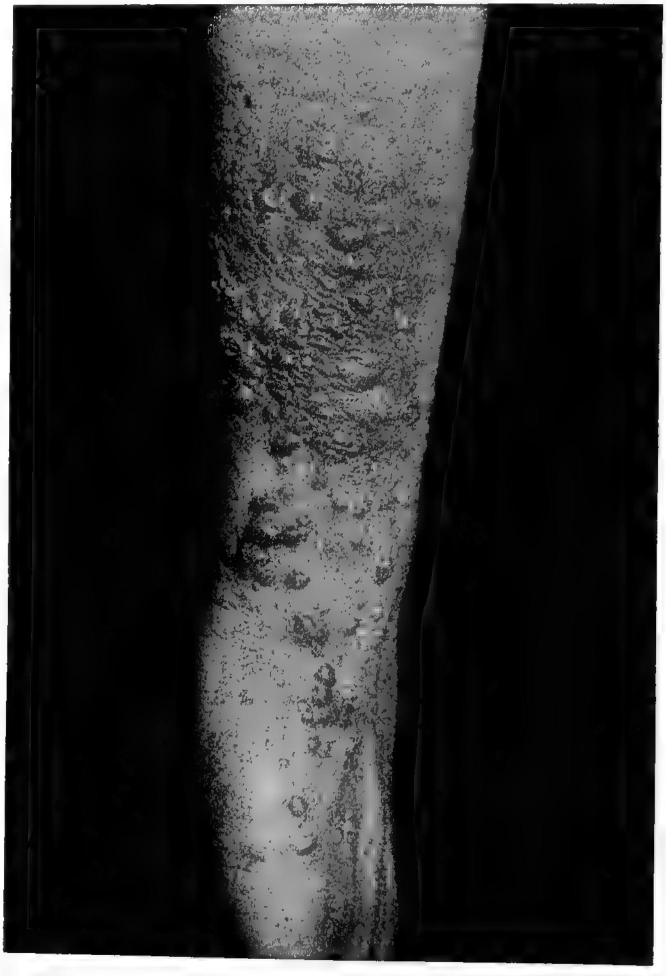

FIG. 1594.—Dermatitis Venenata. (Case of Dr. H. W. Stelwagon.)

An interesting case of this kind came under the author's notice in November, 1898, in a workman, employed in the manufacture of the drug, who exhibited three ulcers: two on the right index finger extended almost to the bone, while the other, more superficial in character, was on the index finger of the left hand. It is stated that, owing to the air being impregnated with the salt in buildings where it is manufactured, the poison gains entrance through the minutest excoriation. Crocker speaks of a French polisher who had repeated pustular eruptions, surrounded by an areola, on the palms. Unguentum hydrargyri, when used carelessly and too energetically, locally, occasionally produces an erythematous or vesicular eruption, "mercurial eczema," and even dermatitis exfoliativa universalis. The author has not infrequently observed an erythematous and vesicular eruption follow the too vigorous application of mercurial ointment for the purpose of destroying pediculi pubis. This eruption was not limited to the pubic region alone, but extended over the anterior part of the chest to the manubrium sterni, and was accompanied by symptoms of mercurial poisoning. The application of croton oil and tartar emetic for the purpose of counter-irritation may give rise to a vesicular and pustular eruption, and permanent scarring may result. Examples of this kind are seen when one makes examinations of the chest. Mustard, cantharides, turpentine, savin, and mezereon all possess the power of setting up cutaneous inflammation. The local use of tincture of arnica, formerly a popular remedy for slight injuries, may be followed by a papular and vesicular eruption similar to rhus poisoning. Inferior articles of soap not infrequently produce a dermatitis. Sapo viridis possesses caustic properties and acts as an irritant when injudiciously applied. Face powders and lotions for the complexion, containing lead or arsenic, and rouge, which is prepared from saffron, are apt to produce cutaneous irritation. There exists a form of dermatitis among workmen who handle paraffin; it affects principally the dorsum of the hands. Individuals who handle lime, flour, and sugar are very prone to develop an eruption, known as "trade eczema." The most frequent and severe form of dermatitis venenata is that occasioned by poisonous species of the rhus family. Rhus toxicodendron, known as poison ivy or poison oak, is very common in the United States; it grows along fences and hedgerows, and around trees to which it is attached by rootlets; it is also met with as a shrub or low tree, when it is known as poison oak. All parts of the plant, particularly the leaves and root, contain a poisonous juice. As it is likely to be mistaken for the Virginia creeper, it is well to add that the poison ivy has but three leaflets, whereas the former has five leaflets.

Rhus venenata, poison ash (or elder, or sumach), swamp sumach, poison dogwood—a shrub or tree, varying in height from six to eighteen feet, and having a trunk from one to five inches in diameter—generally grows in swamps. It possesses more poisonous properties than rhus toxicodendron. The leaves are pinnate, the leaflets oblong or oval, entire or sometimes slightly sinuated and pointed, and number from one to thirteen. The poisonous principle is attributed to the presence of an oil, to which Franz Pfaff has given the name toxicodendrol.

Another very poisonous shrub is rhus diversiloba, the poison oak of the Pacific Coast. Although it resembles rhus toxicodendron to a marked degree, it differs from the latter by being provided with acuminate leaflets.

Rhus pumila, dwarf sumach, growing in North and South Carolina, is regarded by some as the most poisonous species. It is a low, procumbent shrub with from eleven to thirteen oval or oblong, acute, serrate leaflets.

Rhus vernix or vernicifera, known as walnut-leaved sumach, Japan lacquer, or varnish tree, looked upon by some as being identical with rhus venenata, grows in China and Japan. It furnishes Japan varnish and possesses poisonous properties.

Susceptibility to the poisons of these different plants varies greatly in individuals. There are well authenticated cases on record illustrating the susceptibility of certain persons; thus some individuals are even poisoned by passing the plants or when exposed to the smoke of burning vines. This is so well known that in the country even the poorer class of people refuse to burn the wood in their stoves or fire-places. Even the handling of Chinese lacquer work, the varnish for which is obtained from the rhus vernix, as stated above, produces a dermatitis venenata in some. The severity of an attack varies from an erythematous and vesicular condition to a severe eruption, which is frequently accompanied by swelling. The period of incubation varies from a few hours to several days. The symptoms which usher in the disease are burning, heat, and itching which may be very intense. These conditions are generally first observed on the face and hands (lateral surfaces of the fingers), as they are most exposed. From the hands the eruption may extend to the wrists and up the arms to other parts of the body. Not infrequently the swelling is so severe as to cause closure of the eyelids, and the genitalia are frequently involved, owing to the poison being conveyed by the hands to these parts. In very severe cases the œdema may be so great as to interfere with motion, and the subjective symptoms, consisting of itching and burning, may be so pronounced as to render sleeping impossible and to require the administration of narcotics. The eruption may be erythematous in character; the eczematous type, however, is most frequent. Vesicles, the size of a pin's head, situated on an erythematous base, develop rapidly; they may become pustules or may attain the size of blebs. The vesicles rupture spontaneously or are destroyed by scratching or rubbing and exude a yellowish, sticky fluid that dries into yellowish crusts. Usually the disease runs its course in a fortnight, but may be prolonged for several weeks. Very severe attacks are sometimes accompanied by slight rise of temperature, coated tongue, and constipation. Although rhus poisoning cannot, in the strict sense of the word, be regarded as contagious, there are cases on record in which the poison has been conveyed to others by persons who had come in contact with the plant without being poisoned themselves. The poison may be conveyed from the hands to the penis while urinating, which would explain the frequency with which the genitalia are attacked. There exists a popular belief that dermatitis venenata is apt to recur repeatedly during several years; but this, according to White, is due to renewed exposure. Eczema is very prone to follow an attack of rhus poisoning.

Diagnosis.—The diagnosis is generally not difficult, as it is nearly always possible to get a history of exposure to the poisonous plants. There are certain points by which rhus poisoning may be differentiated from vesicular eczema: the eruption is more irregular and more scattered, and it occurs in streaks or patches, suggestive of contact with poisonous plants.

Prognosis.—The cutaneous eruption always has a favorable termination. Grave systemic effects are rare; a fatal case, however, attributable to the poison, has been reported.

Treatment.—The remedies brought forward for the treatment of this disease are very numerous. It will be sufficient to mention those which have proved useful. Sodium bicarbonate or borax (sodii boras) may be applied in powder form to the affected parts. Alkaline lotions will be found efficient, such as the saturated solution of sodium bicarbonate or solution of chlorinated soda (liquor sodæ chloratæ, also known as Labarraque's solution), to be applied in half strength on cloths. A saturated solution of sodium hyposulphite (℞ Sodii hyposulph. ʒ i., aquæ dest. ℥ i.), constantly applied, is a very good remedy. Liquor plumbi subacetatis, in the proportion of one part to three of water, is also serviceable. Its use, however, is contraindicated when the skin is broken. Black wash, lotio nigra, used on cloths, makes a very good application; it must, however, not be used over too large a surface, as it may be absorbed and produce symptoms of mercurial poisoning. Decoction of white oak bark will also be found serviceable. A very reliable remedy is grindelia robusta (extractum grindeliæ robustæ fluidum) ʒ ij.–iv. to aq. dest. O i. The following formula, recommended by Hardaway, may be used advantageously:

℞ Zinci sulphatis .... ℥ i.
Aq. dest. .... O i.
M. S. Apply on cloths and renew every hour.

The author has had good results with aristol, employed in powder form and as an ointment (ʒ ss.–℥ i.).

Quite a number of other plants are capable of causing cutaneous inflammation. According to Dr. J. C. White not less than sixty domestic species possess irritant and poisonous properties when brought into contact with the skin. As it is impossible, owing to lack of space, to enumerate in detail these various plants, the reader is referred to Prof. J. C. White's excellent monograph, "Dermatitis Venenata," Boston, 1887.

Irritants Belonging to the Animal Kingdom.—A large number of insects, as the mosquito, flea, bedbug, wasp, bee, caterpillar, etc., are capable of irritating the skin by means of biting or stinging. Certain lower forms of marine life, as the jelly-fish, notably the Portuguese man-of-war, sea urchins, etc.; human secretions, viz.: urine, perspiration, nasal and aural secretions, may give rise to cutaneous inflammatory phenomena, more or less marked.

The author is indebted to Dr. Henry W. Stelwagon for the accompanying illustration. *Emmanuel J. Stout.*

DERMATOL.—The trade name for the subgallate of bismuth, $BiC_7H_7O_7$, containing fifty-five per cent. of the oxide of bismuth. It is a fine, yellow powder, devoid of odor, quite insoluble in water or any of the ordinary solvents, free from irritating action, and non-poisonous.

It has been introduced to replace iodoform, on account of its freedom from many of the disagreeable qualities of that drug.

It is not a bactericide, but prevents the growth of these organisms, and in this way compares favorably with iodoform and aristol. Its beneficial action is said to be due to its neutralizing the ptomaïns produced. It is not only insoluble but also repels water, thus rendering the part unfavorable to the growth of bacteria. Recently a compound has been formed by adding iodine to dermatol; it is known as *airol.*

It is not so suited to the treatment of sloughing or septic wounds as iodoform, nor is it sufficiently stimulating in chronic indolent ulcers. It is most serviceable as a means of promoting cicatrization in healing surfaces, and in affections of the skin; in burns, scalds, chancres, and eczema, particularly when characterized by much discharge, it has been used with marked success. In these cases the parts become dry on the second or third day after the drug has been first applied, and the relief is very marked. If the part is previously washed with an antiseptic lotion the action of the remedy is greatly assisted. It may be applied by dusting on the part, or in the form of an ointment of one part in ten. It may with advantage replace oxide of zinc, starch, etc., as a dusting powder for scalded and denuded surfaces. In chronic gonorrhœa the following emulsion has been used with success: Dermatol, 2; gum acacia, 2; distilled water, 25 parts.

In doses of gr. xxx. to xc. it has been given internally, as a substitute for the subnitrate, for diarrhœa in children, in phthisis, typhoid, etc., with good results. It may be given in wafers or as an emulsion. *Beaumont Small.*

DERMATOLYSIS.—(Synonyms: Cutis laxa, pendula, pensilis; pachydermatocele; elephantiasis mollis; chalazodermia.)

DEFINITION.—A soft, pendulous, benign tumor of the skin composed of hyperplastic, loosely connected fibrous tissue.

SYMPTOMS.—This variety of tumor is in reality a subdivision of the larger class of new growths known as soft fibromata. It occurs often as a single tumor or at times in association with one or more smaller growths, and it has been observed arising from the face, the eyebrows, the occiput, the neck, the chest, the breasts, the axillæ, the back, the arms, the abdomen, the nates, the thighs, and the labia. It varies in size from its early microscopic origin to its final maximum growth, when it may completely hide the face or may involve and surround a whole extremity in its enveloping folds, or it may cover the whole back, as with an immense pack. The shape of the tumor varies with the position of the patient, for its consistence is so soft that it follows strictly the force of gravity. The soft, spongy consistence is, indeed, one of the most characteristic features of the disease and to the touch the tumor mass feels distinctly soft and yielding and simulates closely the "feel" of fibroma molluscum. The skin which covers the pendulous mass is almost always of a brownish hue and exhibits varying degrees of stretching, and thus we find the follicles far apart and their mouths patulous. At times we may find growing from the surface of the tumor one or more scattered, marble-sized fibromata. A marked characteristic of the more extensive cases is their tendency to grow in folds, which writers have likened to the capes of an old-fashioned driving coat or to the flounces of a lady's dress. At other times the tumors hang in long straight bands—a form well illustrated in an example observed by Hyde.

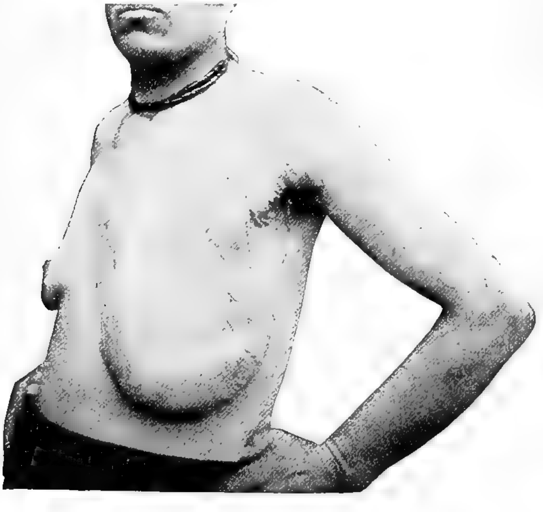

FIG. 1595.—Dermatolysis. (Author's case.)

The subjective symptoms are usually those of physical discomfort due to the presence and weight of the tumor mass, although a few instances of hyperæsthesia have been recorded.

ETIOLOGY.—With dermatolysis, as in all cases of new growths, writers are still in some doubt as to the origin of the new formation. Von Recklinghausen has done much, however, to unravel the mystery of all soft fibrous-tissue tumors and has demonstrated that they are direct outgrowths from the connective tissue surrounding the nerves, glands, hair follicles, vessels, or fat globules of the skin. What determines the hyperplasia in cases of dermatolysis the observer is usually at a loss to account for. Radcliffe Crocker has, on the other hand, described an instance in which one can undoubtedly attribute the origin to trauma. A man fell into the hold of a vessel and received severe injuries which resulted in a tedious ulcer of the nates, which in time yielded to treatment; but the subsequent history was that of a large, pendulous tumor growing from the seat of the original wound.

Instances have been recorded in which dermatolysis has occurred in several generations of the same family or again in members of the same generation, and thus heredity seems to play a definite rôle in a certain percentage of the cases. Sex has no important bearing upon the presence of the tumors.

The tissue change often makes its appearance for the first time in late childhood or the new growth may not develop until the patient is well advanced in years. In the writer's case (a Syrian woman of forty-five years) the tumor was first observed in the left breast at the age of fourteen, while the change in the right breast has existed but a few years (Fig. 1595). As the individual grows older the tumor increases in size, and, if let alone, continues enlarging often for many years, when it finally reaches its maximum size. Dermatolysis is usually a tumor of slow growth, and, if proper cleanliness is exercised, remains free from the intercurrent attacks of erysipelas incident to true elephantiasis, and, as a rule, escapes the ulcerations which appear in the later stages of sarcoma and of epithelioma.

PATHOLOGY.—The microscopical appearances of dermatolysis are characterized principally by changes in the derma and in the hypoderma, but there are, nevertheless, a few minor points to be noted in the epidermis. First, we find a slight disturbance of nutrition in the cells of the stratum spinosum, and secondly, a marked invasion of pigment granules in the stratum germinativum.

In the corium we find a decided increase of elastic fibres which occur in compact bundles distributed at intervals immediately below the epidermis. This hyperplasia of elastic tissue is not noticed in the deeper layers of the derma but is apparently confined to the subpapillary region. Below this line we come upon the tumor proper, which consists of loosely connected bundles of fibrous tissue, rich in cells (among which many mast cells appear) and enclosing in its meshwork many blood-vessels and lymph spaces, and it is the presence of these abundant nuclei, the loose formation of the connective tissue, and the interlying vascular and lymph spaces which render so marked the microscopical contrast between dermatolysis and keloid.

The connective-tissue fibres may possibly undergo a myxomatous degeneration, and at times large foci of jelly-like material may be formed within the tumor mass.

DIAGNOSIS.—The diagnosis of dermatolysis should be, therefore, an easy one. A single tumor of the skin, usually of long duration, arising from almost any part of the body, save the soles of the feet or the palms of the hands, hanging in one or more folds or simply pendulously from its point of support, distinctly soft and elastic in consistence, covered with a brownish, stretched integument, should suggest most strongly pachydermatocele.

The consistence, the absence of œdema, the rarity of intercurrent attacks of erysipelas and of other forms of dermatitis, the frequent seat of the lesion on parts of the body unknown as points of departure in true elephantiasis should render the differential diagnosis between dermatolysis and elephantiasis Arabum a comparatively positive one.

The large size, the dependence, the frequent occurrence in folds and convolutions should exclude the probability of lipoma.

The pendulousness, the brown rather than the dull red or purplish color, the continued good health of the patient, the absence of metastases or of ulcerations should exclude the possibility of sarcoma; and, finally, the fact that the tumor is large, that it is pendulous, and that its covering is usually brown should lead the diagnostician to place this new growth in a separate division from the more frequent cases of multiple fibroma which it so closely resembles histologically.

PROGNOSIS.—From the description of the disease already given we can see that dermatolysis should cause its unfortunate possessor no fear of serious results, for the tumor forms no metastases and undergoes ulceration but rarely. The patient has to dread, therefore, only the disfigurement when the disease exists upon the head, the face, or the neck, or the sense of weight when the tumor attains large size, and finally the rather remote possibility of transmission to his descendants.

It will be seen that the writer has made no mention in this article of cases of elastic skin—the so-called cutis elastica seu hyperelastica. This is an intentional omission, for the writer believes that this condition of the skin is quite apart from the consideration of dermatolysis and should be considered under its own heading.

TREATMENT.—There is only one form of treatment and that lies in the removal of the tumor with the knife.

Charles J. White.

DERMOID CYSTS. See *Cysts.*

DERMOL.—$Bi(C_{15}H_9O_4)_3Bi_2O_3$—bismuth chrysophanate. This is an amorphous yellow powder obtained by precipitating a solution of chrysophanic acid neutralized by soda with a solution of bismuth nitrate. It combines the values of chrysarobin and bismuth, and is used in ointment or powder in such parasitic skin diseases as pityriasis, favus, ringworm, etc. *W. A. Bastedo.*

DES CHUTES HOT SPRINGS.—Crook County, Oregon. These springs are located 8 miles north of Warm Springs. They issue from the base of the cliffs along the valley of the Wam-Chuck River. Their number is quite large, and some of them have a copious flow. The temperatures of two of them are respectively 143° and 145° F. Analysis by L. M. Dornbach and E. W. Horsford showed the following results:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium carbonate	34.50
Sodium sulphate	9.46
Calcium sulphate	1.82
Sodium chloride	20.42
Potassium chloride	2.00
Magnesium chloride	1.21
Sodium silicate	8.20
Iron	Trace.
Total	77.61
	Cubic inches.
Carbonic acid gas	22.56

This analysis shows a valuable combination of mineral ingredients. So far as we are able to learn, however, the springs have not been improved as a resort.

James K. Crook.

DESMOID TUMORS.—(Desmoid, tendon-like.) This designation has been applied to that variety of hard fibroma which on section creaks under the knife, and shows a cut surface resembling more or less that of a tendon.

These growths form as a rule circumscribed tumors, varying in size from a mustard seed to a man's head or even larger; and are round, nodular, or lobulated. They usually possess a definite capsule, and grow entirely by expansion. Their consistence is very hard and firm. On section they show a white, glistening, tendon-like surface in which the whorled and interlacing bundles of coarse fibres of connective tissue are often visible to the naked eye. The cut surface is dry or but very slightly moist. Occasionally the color is pink or reddish. To the naked eye few blood-vessels are usually visible, but microscopically these growths may be found to possess a well-developed system of vessels. Occasionally the latter may become angiectatic, whereby the cut surface of the growth is mottled red and white.

The finer structure of these growths consists almost entirely of fibrous connective tissue, either arranged in coarse fibres or appearing almost hyaline and homogeneous. The intercellular substance far exceeds the cells in amount, the latter frequently being present in very small numbers and widely separated by the hyaline intercellular substance. In some portions of the growth the cells may entirely disappear, leaving only the hyaline intercellular substance, which eventually becomes calcified or undergoes liquefaction. Retrograde changes are very common in these growths: hyalin, calcification, necrosis, liquefaction following œdema or myxomatous degeneration, gangrene, etc.

Desmoid tumors are found most frequently in the subcutaneous tissue, intermuscular connective tissue, nerve sheaths, retroperitoneal tissues, serous membranes, etc., in which regions they may reach a large size. Small growths of a similar nature occur less often in the mammary gland, parotid, and kidneys, and more rarely in the ovaries, liver, and spleen. Uterine myofibromata containing but a small proportion of unstriped muscle assume the appearance of desmoid fibromata. The so-called desmoids of the abdominal wall are in reality spindle-cell fibro-sarcomata of slow malignancy, but differing from the fibromata in that they grow by infiltration. The true desmoid is malignant only by size, position, and tendency to necrosis. It does not infiltrate nor give rise to metastases. If removed with its capsule entire it will not recur.

Aldred Scott Warthin.

DES MOINES, IOWA.—Situated in the central portion of the State of which it is the capital, upon the Des Moines River. It is of considerable size and importance. The climate is indicated by the accompanying table:

CLIMATE OF DES MOINES, IOWA—LATITUDE, 41° 35′; LONGITUDE, 93° 37′; PERIOD OF OBSERVATIONS, FIVE YEARS FIVE MONTHS.

Data.	January.	July.	Year.
Temperature (degrees Fahr.)—			
Average or normal	20.9°	73.8°	49.0°
Average daily range	19.2	19.4	
Mean of warmest	29.4	84.7	
Mean of coldest	10.2	65.3	
Highest or maximum	63	98.5	
Lowest or minimum	−26	52	
Humidity—			
Average relative	71.1%	71.2%	69.0%
Precipitation—			
Average in inches	1.06	3.37	41.35
Wind—			
Prevailing direction	N.W.	S.W.	S.W.
Average hourly velocity in miles	6.3	5.1	6.4
Weather—			
Average number clear days	11	10.6	111.2
Average number fair days	11	14.2	151.3
Average number fair and clear days	22	24.8	262.5

E. O. Otis.

DETROIT.—The chief city of Michigan, of over 200,000 inhabitants, is situated on the northern bank of the Detroit River, connecting Lake Erie and Lake St. Clair, and forming the boundary between the United States and

Canada. The climate of Detroit is represented by the following chart.

CLIMATE OF DETROIT, MICH.—LATITUDE, 42° 20′; LONGITUDE, 83° 3′ PERIOD OF OBSERVATION, DECEMBER 1ST, 1870, TO DECEMBER 31ST, 1883.

Data.	January.	July.	Year.
Temperature (degrees Fahr.) –			
Average or normal	24.8°	71.6°	47.9°
Average daily range	12.7	18.4	
Mean of warmest	31.3	81.4	
Mean of coldest	18.6	63	
Highest or maximum	65	100	
Lowest or minimum	−15	50	
Humidity–			
Average or relative	78.3%	70.0%	71.6%
Precipitation—			
Average in inches	2.14	4.14	35.41
Wind—			
Prevailing direction	S.W.	S.W.	S.W.
Average hourly velocity in miles	8.2	6.4	7.8
Weather—			
Average number clear days	3.8	9.8	85.9
Average number fair days	9.6	14.9	147.8
Average number of fair and clear days.	13.4	24.7	233.7

E. O. Otis.

DEXTRIN.—"*Artificial Gum.*" ($C_6H_{10}O_5$.)—A polysaccharide, of the same formula as starch, cellulose, inulin, and lichenin. The name is applied to any one or all of the intermediate substances produced in transforming starch or cellulose into glucose. The first member of this series, *amylodextrin*, yields a purple color with iodine, but all the others show no color with that reagent which could even carelessly be mistaken for that of starch. Commercial dextrin is a white or yellowish-white substance, powdery or compacted into lumps, with a specific gravity of 1.038 and soluble in water. It is produced by the action of either diastase or dilute mineral acids, aided by heat, upon starch. Dextrin itself does not admit of fermentation, but upon being converted into *dextrose* by the addition of a molecule of water, it does so and can then pass on into alcohol. Dextrin bears a close relation to gum and its chief use is to substitute that article, much of such use being fraudulent. It can be distinguished by its peculiar odor and by the test given under *Gum.* Alcohol precipitates it. It is highly adhesive but distinctly inferior to gum, its solution growing very dark with age. Dextrin is itself very prone to adulteration, especially with starch. Commercial dextrin often holds an excessive amount of water, as well as of dirt of various kinds. Dextrin has no medicinal properties but, being partly digested starch, it forms a common ingredient of artificial foods for infants. *Henry H. Rusby.*

DIABETES MELLITUS.—DEFINITION.—A diminution of the sugar-consuming power of the body tissues resulting in a more or less permanent glycosuria. Of the cause and nature of saccharine diabetes we are practically ignorant. We distinguish the symptom glycosuria from the disease diabetes, but the distinction is merely one of time, since we cannot refuse the title of diabetes to any long-standing glycosuria, no matter what the other symptoms are. The weakness of this position is obvious; we are making the distinction between a symptom and a disease one wholly dependent upon time.

Temporary glycosuria may be brought about by any one of a number of causes, among which perhaps the commonest are profound narcosis (whether produced by alcohol, ether, or any other drug), profound coma, however produced, poisoning by carbonic oxide, nitrite of amyl, or strychnine, and the active use of diuretics. Such glycosuria must be distinguished from the lactosuria which sometimes occurs toward the end of pregnancy and during lactation, as well as from the dextrosuria produced by large doses of chloral or chloralamide. Less frequent causes of glycosuria are traumatic neuroses, alcoholism, delirium tremens, hysteria, neurasthenia, chlorosis, Graves' disease, and the infectious fevers. I need hardly say that glucose must be distinguished from other copper-reducing substances which are not very infrequently present in the urine when the latter is very concentrated and after the ingestion of certain poisons (see, below, tests for sugar). It must not be forgotten that the capacity of the individual for burning up grape sugar is never an unlimited one. Glycosuria may be produced in any one by the ingestion of a sufficiently large amount of glucose, and is then known as "*alimentary glycosuria;*" it can ordinarily be produced by taking 200 gm. of glucose upon a fasting stomach. In many persons the tolerance for sugar is less than this.

Although diabetes cannot be said to be a disease of any one organ, yet it is indubitably true that in a minority of cases some organic lesion is to be found. Thus a certain proportion of cases occurs in connection with diseases of the liver (especially cirrhosis) and with disease or trauma of the nervous system, especially cerebral tumors. Those pressing upon the floor of the fourth ventricle are not by any means the only tumors which are capable of being associated with diabetes. Other diseases of the brain occasionally associated with diabetes are cerebral hemorrhage, dementia paralytica, and the various forms of meningitis.

Of late years it has been shown that diabetes may occur in connection with any one of the various diseases of the pancreas. This connection is not, however, a very intimate one, since no lesion of the pancreas can be found in the majority of cases of diabetes and it is not at all uncommon to find pancreatic disease without diabetes. Finally, it should be mentioned that gout, obesity, and arteriosclerosis are very frequently present in cases of diabetes, though whether as cause or effect of the diabetes, or as a result of some deeper cause of which diabetes is another manifestation, we do not at present know.

The tendency to diabetes is in all probability capable of being inherited. Sometimes the morbid tendency shows itself in one member of the family as diabetes, as obesity in another, and as gout in a third. The occurrences of cases in husbands and wives are probably accidental. All ages and both sexes are affected.

All the etiological factors hitherto mentioned, except heredity, are concerned only in a minority of cases. For diabetes in a great majority of cases no cause, no associated disease, no inheritance can be assigned. The disease comes, as we say, of itself.

SYMPTOMATOLOGY.—Most of the symptoms of diabetes may be regarded as results of the glycosuria, but it is convenient to divide them into the more *direct* and the more *indirect* results. In the former class are hunger, thirst, polyuria, emaciation, and muscular weakness. The thirst in well-marked cases is so great that the patient goes to bed with a four-quart pitcher of water at his side and empties it before morning. It is related that a diabetic patient was paid to stay away from a hotel conducted on the American plan owing to the disastrous ravages which his hunger made upon the bill of fare. This anecdote, whether true or not, gives some idea of the voraciousness of a diabetic's appetite. Four or five quarts of urine are frequently passed in twenty-four hours and the amount may be much larger. As a result of this drain upon the tissues the patient is apt to emaciate rapidly and to notice great muscular weakness. This is especially the case when the disease occurs in persons under thirty-five years of age and in those whose habit of body is spare. In cases occurring in fat old people there may be little or no weakness or emaciation (see below).

In the presence of these symptoms: *thirst, voracious appetite, emaciation, muscular weakness, and polyuria*, or of any one of them, the examination of the urine for sugar is immediately suggested and imperatively demanded.

The test for sugar is best performed with Fehling's solution, the formula for which is as follows: Dissolve 34.64 gm. of pure $CuSO_4$ in 500 c.c. of water; dissolve 173 gm. Rochelle salts and 60 gm. sodium hydrate each in 200 c.c. of water. Mix and add water up to 500 c.c.

The copper solution must be kept in a separate bottle and not mixed with the alkali until we are ready to make the test. Equal parts of the two solutions are then mixed in a test tube and the mixture is boiled. Should any precipitate appear on boiling, the solution must be rejected and another portion freshly prepared. If no precipitate appears, add an amount of urine equal to the amount of the hot Fehling's mixture in the test tube. If sugar is present in the suspected urine a yellow precipitate will appear—usually within a few seconds, occasionally after the lapse of some hours. This precipitate is due to the reduction of the copper and can be produced in case reducing substances other than sugar are present in the urine; this, however, is very rarely the case. Large amounts of uric acid are capable of reducing copper, but only in a solution more concentrated than often occurs in urine. In any case of doubt the presence of sugar may be verified by the fermentation test (see below). In the vast majority of cases, however, Fehling's test is all sufficient for a qualitative examination for sugar.

Having satisfied ourselves that sugar is present, we proceed to estimate its amount. This is best performed by means of the fermentation test. First take the specific gravity of the urine; then to four or five ounces of urine add one-half cake of Fleischman's yeast in an open beaker, crumbing up the yeast into small pieces while adding it. Set the beaker aside in a warm place for thirty-six hours, then filter its contents and take the specific gravity of the filtrate. If sugar is present the filtrate will be found to be much lighter than before the addition of the yeast. To estimate the percentage of sugar, multiply the number of degrees of specific gravity lost by 0.237 and the resulting figure represents the percentage of sugar. Thus, if the specific gravity of the urine before fermentation were 1.040 and after fermentation 1.020 the resulting loss of specific gravity of 20 degrees multiplied by 0.237 gives us 4.74 per cent. of sugar. If the amount of urine passed in twenty-four hours is previously known, we can easily estimate the twenty-four hours' output of sugar, which is, of course, the essential point to be ascertained. For practical purposes these two tests, the qualitative test with Fehling's solution and the quantitative test by means of fermentation, are all sufficient. The tests for acetone, for diacetic acid, and for beta-oxybutyric acid will be described later.

INDIRECT SYMPTOMS OF DIABETES.—The drain upon the tissues produced by the excretion of large amounts of sugar which ought to be absorbed and utilized in the body is manifested directly in the symptoms already mentioned, viz., hunger, thirst, emaciation, muscular weakness, and polyuria. Indirectly the increased vulnerability of the body tissues manifests itself in some one or more of the following ways:

1. Lesions of the skin and mucous membranes.
2. Lesions of the nervous system.
3. Lesions of the respiratory system.
4. Lesions of the circulatory system. Each of these will now be taken up in detail.

1. *Lesions of the Skin and Mucous Membranes.*

(*a*) An abnormal *dryness* of the skin and mucous membranes is almost invariably present. The skin becomes rough and harsh and its appendages, the hair and nails, show the effects of malnutrition in dryness and brittleness.

(*b*) *Eczema* about the genitals is a very significant symptom and may be the first thing to suggest the diagnosis of diabetes. A red and angry eczema about the vulva should invariably suggest to us to test the urine for sugar. Balanitis and vulvitis are not so common, but they occasionally occur. Generalized eczema and other dermatoses are less common.

(*c*) *Furunculosis* and other staphylococcus affections of the skin manifest the diminished resisting power of the cutaneous tissues.

(*d*) *Carbuncle* is not infrequently associated with diabetes and the presence of such a suppurative process should always suggest a search for sugar in the urine. Diabetic gangrene is considered by some to belong in this category of changes, but it seems to me best to consider it under the lesions of the circulatory system (see below).

2. *Lesions of the Nervous System.*

(*a*) *Diabetic Neuritis; Neuralgia.*—Sciatica, intercostal neuralgia, trigeminal neuralgia, and less frequently brachial neuralgia appear as results or complications of diabetes and may be the first indication of the disease. This is especially true of sciatica. (*b*) Muscular cramps, unusual muscular fatigue on slight exertion, and deep muscular pain are sometimes associated with diabetes. Twice patients have come to me complaining only of cramps in the calves and totally unaware of any underlying disease. (*c*) Loss of knee-jerk characterizes relatively late stages of the disease in the majority of cases and is probably due to a peripheral neuritis. (*d*) Facial paralysis of peripheral origin may be the first symptom which leads the patient to consult a physician. Other peripheral paralyses are less common. (*e*) Anæsthesia and paræsthesia usually affecting relatively small areas are not at all uncommon. The inner and anterior aspects of the thigh are not infrequently affected and the disturbances of sensation may be associated with pain (meralgia paræsthetica). (*f*) Perforating ulcer of the foot (mal perforans) is undoubtedly to be referred to a nervous lesion and is a fairly common manifestation of diabetes.

Lesions of the brain and cord are much less common than those of the peripheral nerves and when present are often to be explained as results of the arteriosclerosis with which diabetes is so frequently associated. In one of my cases there was for many months an intense generalized headache apparently of cerebral origin. Loss of sexual power is an important and sometimes an early symptom.

Lesions affecting the special senses are not frequent, if we except the eye. Among ocular lesions by far the commonest is *cataract*—a disease which may give us the first suggestion of the possibility of diabetes. Retinitis is not very uncommon. Paralysis of the abducens is not infrequent and many diabetics develop at an early age the far-sightedness which is so common in elderly people. Occurrences of hemiplegia, of convulsions, and of coma in cases of diabetes will be discussed later.

3. *Lesions of the Respiratory System.*

(*a*) Pulmonary tuberculosis complicates from seventeen to fifty per cent. of all cases of diabetes. Between these figures the statistics of different writers vary. It hardly ever occurs in elderly or obese diabetics and usually runs a rapid course to the fatal termination. Hæmoptysis is notably rare and there is often but little expectoration. In a young man who died after withstanding the disease for nine years under my observation, there was found at autopsy a pneumonic form of tuberculosis presenting solidification of the whole right lung from top to bottom without cavity formation. During life there were no sputa and practically no cough. As a result of the swallowing of sputa the intestine is not infrequently attacked by tuberculosis. (*b*) Pulmonary gangrene. About five per cent. in all cases of diabetes are attacked by gangrene of the lung which may run a rapid course or drag along for months and even years. (*c*) Croupous pneumonia. Diabetic cases of the severe type often end with an acute pneumonia. In all cases of pneumonia the urine should be examined for sugar; its presence greatly darkens the outlook. (*d*) The acetone odor of the diabetic breath is a very characteristic one and may sometimes be detected as soon as one opens the door of a patient's house; it has been variously compared to the odor of chloroform, of rotten apples, and of new-mown hay.

4. *Lesions in the Circulatory Apparatus.*

Arteriosclerosis with its manifold results includes all the circulatory complications of diabetes. Arteriosclerosis is probably to be regarded as a concomitant or a possible cause of diabetes (Naunyn) rather than as a result. Diabetic gangrene is usually, I think, to be regarded as a result of the arteriosclerosis rather than as a manifestation of simple malnutrition. The gangrene affects the extremities following the distribution of the smaller arteries as in ordinary non-diabetic gangrene.

The other manifestations of arteriosclerosis, such as myocarditis, chronic interstitial nephritis and cerebral hemorrhage, are not very uncommon, but do not usually thrust themselves into the foreground of the clinical picture. I may mention here a peculiarity of the complexion in diabetics which I have frequently had occasion to observe. In my experience diabetics are very seldom pale and are quite apt to show a beefy red color of the cheeks. This is especially true of the cases occurring in thin, young people.

Clinical Course of the Disease.—Leaving out of account the rare, acute forms of diabetes, we may divide the great majority of all cases into two main types: 1. The thin, young cases. 2. The old, fat cases.

Occasionally one sees a patient who belongs in neither of these categories, but this is rarely the case. Between these two clinical types the difference is so great that it sometimes seems as if we ought to call them different diseases. Diabetes in the elderly and obese may exist for a considerable time undiscovered and when discovered may give rise to so little inconvenience that we hesitate to class it as a disease. Between this condition and that of the young thin cases there is the sharpest possible contrast. In thin, young people polyuria, hunger, thirst, and emaciation are usually from the first intense and disabling and rapidly increase unless aggressive treatment is begun or even in spite of such treatment. The glycosuria may be diminished and for a time abolished, but it almost always returns in a more obstinate form and this time to persist despite any and all therapeutic measures, reducing the patient within a couple of years to a deplorably weak, emaciated, helpless creature, who may at any time be seized with the fatal coma. In fat, old cases, on the other hand, the amount of sugar excreted is usually relatively small, the patient emaciates but little, the hunger and thirst are usually relieved by a moderately strict diet, and the patient often lives out the natural term of his life and dies of some other affection. Between these two main types there are, as has been said, occasional intermediate forms, *i.e.*, severe cases occurring in stout old people, or relatively mild cases in the young and spare, but it is rare for a case in which the disease attacks a patient before the thirtieth year, to last more than three years. The duration of the disease depends to a considerable extent upon the character and circumstances of the patient. If the sufferer be well off and have the pluck and determination necessary to adhere to the tiresome diet, life may be considerably prolonged. I have known such a case which showed itself at the age of twenty-two in a young college athlete and lasted eleven years before the fatal termination.

The presence or absence of complications also determines to a considerable extent the duration of the disease. All the complications above mentioned occur more frequently in the younger and severer cases, but are by no means confined to such, and when they do attack a patient who is suffering from the milder type of the disease, and who would therefore naturally be expected to live many years, they may shorten life very considerably. Thus a diabetic gangrene or pulmonary tuberculosis may attack even the mildest case and prove more serious than the original disease.

Recovery from diabetes does occur. On this point Naunyn, von Noorden, and all the best authorities are agreed, but it is exceedingly rare and takes place almost exclusively in cases which are nipped in the bud as a result of vigorous treatment undertaken very early in the course of the disease. Such early and vigorous treatment it is very seldom our fortune to be able to administer, but occasionally when the disease is suspected in the children of diabetic parents and when regular tests of the urine are made at stated intervals, whether the children be sick or well, the first advent of the disease is noted and its course can then sometimes be checked.

Coma and Sudden Death in Diabetes.—Typical diabetic coma occurs in not more than one-half of all cases. Many authors find it in a still smaller percentage. It is especially apt to occur in the cases of so-called pure diabetes, *i.e.*, those in which no organic lesion can be found as cause. The majority of cases occur in young, thin patients. Out of eighty-seven cases collected by Blau,* only thirteen had passed the fortieth year. Diabetic coma is preceded by an intense dyspnœa of a peculiar type. The air on entering the lungs meets no resistance, but the patient breathes deeply and rapidly. There is no cyanosis. The attack is often preceded by restlessness or apathy. fever, indigestion, vomiting, headache, and subnormal temperature. The amount of sugar in the urine at the time of the occurrence of coma may be either large or small, but most cases occur while the patient is upon a strict diet and especially in those who have suddenly been put upon a strict diet without other treatment. The dyspnœa may cease only to return after some hours or days, but usually a coma gradually develops. Diabetics may become comatose without any of the features which we have been describing as characteristic of the diabetic coma, *i.e.*, without any of the typical dyspnœa, and there may or may not be epileptiform convulsions. Many diabetics die of rapid heart failure, and rarely there is a sudden collapse such as might occur in apoplexy, yet without any such cause discoverable post mortem. It seems to be agreed by all the best writers upon diabetes that death is brought about in a great majority of cases through an acid poisoning of the system (acidosis). Beta-oxybutyric acid is now believed to be responsible for the toxic condition. The occurrence of acid substances such as diacetic acid in the urine is accordingly to be considered a sign of the presence of allied acids in the blood and tissues and so a sign of an unfavorable prognosis. Treatment directed to neutralizing the abnormal acidity of the body fluids is accordingly undertaken whenever the reaction for diacetic acid is strongly marked in the urine (see below). Acetone and diacetic acid do not usually have any direct causative influence in the production of coma. They are present in large quantities in the urine whenever the albumin of the body is being destroyed, whether by reason of starvation or of poisoning of the tissues by ptomaïns. Acetone and diacetic acid may be present in the urine for weeks or months at a time and yet disappear entirely. On the other hand, when beta-oxybutyric acid appears in the urine, it is usually permanent and shows a lasting tendency to increase, and in most cases within a few days or weeks diabetic coma and death ensue.

The test for diacetic acid is as follows: A few drops of a strong aqueous solution of ferric chloride is added to a test tube full of urine. A deep Burgundy red shows the presence of diacetic acid. Normal urine is only slightly tinged by the brownish tint of the ferric chloride.

Acetone is present if, in a sixth of a test tube full of urine to which a crystal of sodium nitro-prusside has been added, a purple color is produced when we add NH_4OH to strong alkalinity and shake.

Treatment.—A year or two ago much hope was felt that through the use of pancreatic extract a specific etiological treatment for diabetes might be attained whereby the cause of the malady could be met and removed. That hope has proved unfounded and the therapeutics for diabetics still consists, as it has for so many years, in careful diet. Briefly stated the diet for diabetics is one as rich as possible in fats, which with proteids are expected to make up for the total exclusion of carbohydrates from the dietary. An intelligent diabetic sometimes asks what the purpose of this diet is. "It seems to me," said one such patient, "it is about as broad as it is long. Without treatment, I get no use out of part of my food, because it is passed out through the urine. But under your diet, I also get no use from this portion of my food, because I am not allowed to eat it at all. Why doesn't it come to the same thing?" For three reasons: 1. Because we hope, through giving a rest to the tissues which have to do with the burning up of the grape sugar, to re-establish in these tissues their normal sugar-consuming power. Patients who have been altogether deprived of carbohydrates for weeks or months sometimes get back their power of absorbing carbohydrates so that their glycosuria ceases. 2. Because the symptoms which are rendering the patient's life miserable can in a great majority of cases be considerably relieved or abolished. The thirst, the torturing dryness of the mouth, the constant drinking and passing of water, the cutaneous infections are almost always relieved for a time and perhaps permanently. 3. We also hope to prevent the occurrence of complications such as phthisis, cataract, or gangrene which might prove fatal if the glycosuria were allowed to persist. Moreover, we cannot insist too strongly that the dietetic treatment of diabetes relies not merely on cutting off certain foods, but on prescribing an increased amount of certain other foods, *i.e.*, of fats. In diabetic diet lists there should be three classes of food: (1st) those that he *must* take, (2d) those that he *may* take, and (3d) those he *may not* take. To begin with, it is best to weigh out for the patient a two-ounce lump of butter; this amount he must eat each day in one form or another. It need not be weighed out each day if its bulk is approximately known. Next, we must insist that the patient must put cream on everything on which it is possible to eat cream. Salad dressing made with olive oil should be used as plentifully as possible with whatever green vegetables are taken, and sauces containing butter and olive oil should be eaten with fish of various kinds. Bacon, because of the large amount of fat which it contains, should form a part of every diabetic's dietary; with eggs it makes a good breakfast dish. Cheese, especially cream cheese, should be insisted upon, and with any meat the patient takes he should be advised to take as much fat as his appetite will allow him. Other foods which contain a large amount of fat are German sausage, mackerel, salmon, eels, and smoked ox tongue.

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* See Schmidt's Jahrbuch for 1884, p. 88.

In the second group—the foods permitted, though not of as great value as the fats—come all the muscular parts of the ox, calf, sheep, pig, deer, wild or domestic birds, together with the tongue, heart, brain, sweetbreads, kidneys, and marrow bones. All of these must be served in their own gravy, or with mayonnaise, or some other non-farinaceous sauce. All kinds of fresh or dried fish, especially canned fish such as sardines and anchovies in oil, are of value. Shell fish such as oysters, crabs, shrimps, and lobster are allowable, although the liver of the oyster contains a small amount of sugar. Among vegetables only those that grow above ground are permissible, for example, lettuce, spinach, asparagus, cauliflower, cabbage, cucumbers, onions, watercress, Brussels sprouts, olives, sourcrout. Clear soups and broths can be thickened with eggs, marrow, or with cream. Among fruits sour oranges and peaches are allowable. The diet just described is what is known as strict diabetic diet, but we must always remember the aphorism of von Noorden: "Under all circumstances the diet in diabetes must be so ordered that the strength of the patient may be thereby maintained and as far as possible increased." If a diabetic diet does not produce this effect it must be modified. As a rule, we have to modify the regimen during some portion of each year, either because the patient cannot be made to adhere to the strict diet, or because he does not do well under it. It is a good rule, however, in all severe cases to subject the patient at least three times a year, and if possible four times a year, to a course of strict diabetic diet for at least four weeks. In the intervals restricted amounts of carbohydrates may be allowed. How much is to be allowed is to be settled by the temperament of the patient and by the effects upon the urine and general nutrition. It is often necessary to allow the patient one or two slices of white bread, or a quart of milk. In the mild forms of the disease, such as often occur in fat old patients, it is not always necessary to modify the diet at all. I have seen patients who got on apparently perfectly well for years, eating the while whatever they chose, but, as a rule, such patients come to grief in a year or two and are led to put themselves again in a physician's hands by the occurrence of thirst, polyuria, and emaciation, or by the presence of furunculosis or gangrene. In such cases, when we have once freed the urine from sugar by a few weeks of strict diet, we may experiment to discover what amount of carbohydrates the patient can tolerate without producing marked glycosuria. Many such cases will do perfectly well if sugar, pastry, rice, preserves, and dishes made from flour or flour preparations are forbidden. The patient may then be allowed to eat all the bread and potatoes he desires. If the amount of sugar excreted under this diet is not more than 10 or 20 gm. in twenty-four hours and if the patient does not emaciate rapidly it is not necessary to put him on any stricter diet. The treatment by exclusive milk diet (not skim milk) is useful in mild cases, but not applicable in severe ones. A manœuvre which is sometimes beneficial in severe cases is entire abstinence from food for a period of twenty-four hours. I have known this procedure to cause a long-standing and obstinate glycosuria to disappear for a time altogether, although strict diet continued for many months had not succeeded in producing this effect. The disappearance so produced, however, is not usually of very long duration.

Diabetic Breads.—The great majority of diabetic breads in the market are frauds and contain as much starch as ordinary wheat bread, or even more. Bread made from almond meal and eggs can be procured, but it is not usually palatable after a short time. The Soja bean flour, judging from the samples analyzed in Boston, is not trustworthy and often contains considerable amounts of starch. The best bread that I have seen used is made as follows: Take four ounces each of Graham flour and fresh bran (the latter should be obtained through a first-class apothecary and as fresh as possible). Mix with two eggs so as to make a thin batter, add a teaspoonful of baking powder, warm some gem pans and pour the batter in while the pans are warm; it will then rise and when baked make a fairly palatable bread containing about twelve per cent. of starch, and enabling a patient to get down much more butter than would otherwise be possible.

Alcoholic Beverages.—All German writers prescribe alcohol as an important part of the dietary of diabetics both for its calory value and as an aid to appetite and digestion. Thus, von Noorden, in his sample bill of fare for moderately severe cases, advises a glass of cognac for breakfast, one-half bottle Moselle for lunch, another glass of cognac for five o'clock tea, one-half bottle Burgundy with dinner, and another glass of cognac at ten o'clock. For those used to drinking wine with their meals and to consuming beer in the quantities habitually used by most Germans, this amount of alcohol is no doubt useful. In this country and among those not accustomed to the habitual use of stimulants, it does not seem to me advisable to prescribe alcohol in this routine way.

Exercise.—There is no question that muscular exercise is of advantage to many diabetics and that glycosuria is in many cases diminished by muscular work. Unfortunately this is not always the case, and it is only by experimenting that we can find out whether it is best to advise muscular exercise. Horseback riding, cycling, and rowing are of especial value. Exercise is best taken in the morning and followed by a long rest.

Care of the Skin.—We have already seen how frequent are cutaneous diseases in diabetes. These may be to some extent warded off by absolute cleanliness. Frequent changes of underclothing are absolutely necessary. A sponge bath morning and night should never be omitted and the genitals should be cleansed with particular care. No rule can be laid down regarding the temperature of the baths. Some diabetics react as well as healthy persons to cold bath; others do not. When a good reaction follows a cold bath, this is doubtless best.

Medicinal Treatment.—In cases in which nervous irritability is associated with the glycosuria, sedative drugs, such as the bromides, antifebrin, or suphonal, are indirectly beneficial through lessening the nervous irritability. I have never seen any good results from the use of opium or codeine except in the last stages, when they may promote comfort to a certain extent by diminishing the polyuria.

Treatment of Complications.—All operations upon diabetic patients are dangerous, for the wounds heal badly and readily become the starting-point for wide-spreading gangrene. It is rarely well to open a boil, which should be treated, like furunculosis, by a strict diabetic diet. Carbuncles, however, must be operated upon despite the above-mentioned dangers. Ether is here much preferable to chloroform as an anæsthetic.

Should gastro-intestinal catarrh attack a diabetic patient, it may prove very serious if not speedily arrested. Complete starvation for twenty-four hours, and small doses of calomel followed by paregoric are useful. Stimulation with brandy every four hours should be kept up during the period of starvation. The treatment of pulmonary tuberculosis in diabetics is very unsatisfactory. Its occurrence may be a sufficient reason for a change of climate, but diabetics do not bear high altitudes well, and the main point in changing climates is to find one where the patient can be out-of-doors most of the time.

Treatment of Threatened Diabetic Coma.—When we have warning that coma is impending owing to the excretion of large amounts of diacetic acid in the urine, it is well to make some modification of the diet. Von Noorden says that the fact of a change seems to be more important than the direction in which this change is made. If the patient is upon a strict diet, there should be given a certain amount of carbohydrates; on the other hand, if he is taking carbohydrates in considerable quantities a strict diet should be resorted to. If constipation is present, it should be relieved by enemata or mild laxatives. Acting on the now fairly well-established theory that diabetic coma is an acid intoxication, it is worth while to give large doses of alkalies—for example, two drachms of bicarbonate soda every four hours with a bottle or two of Vichy water. If actual coma supervenes and it is desirable to keep the patient alive for a few hours in order that he may make his will, or await the arrival of a friend, the intravenous injection of a litre of three-per-cent. sodium bicarbonate in 0.6-per-cent. salt solution may be followed by a return of consciousness of sufficient duration to accomplish the desired result.

Richard C. Cabot.

DIAMIN, $2[(NH_2)_2H_2SO_4]$.—Hydrazin sulphate diamidogen. This is a powerful antiseptic made by heating diazoacetic acid with sulphuric acid. It forms colorless crystals soluble in hot water. *W. A. Bastedo.*

DIAPEDESIS.—Gould's Medical Dictionary defines it as "The escape of the elements of the blood, especially the white corpuscles, through the vessel wall."

The term is vague and needs modification. When first the phenomena of inflammation were watched under the microscope, and the migration of the white blood corpuscles from the uninjured vessels were followed into the injured tissue, diapedesis seemed a plain and simple process. When additional investigations demonstrated that the same phenomenon takes place in healthy organs, and merely goes on at a faster rate in pathological conditions, the process seemed less simple; and since it has been asserted that the white blood corpuscles are not of one kind, but of several varieties, and that their work is complex and manifold, the term diapedesis at present covers a series of different phenomena. At the outset we have to divide it into a passive and an active form, or into a mere mechanical and a vital process. The escape of plasma and red blood corpuscles through injured vessel walls is always the same, and is determined by the blood pressure and the extent of the injury; it is self-limiting and stops as soon as a clot is formed or as soon as the pressure in the tissues surrounding the injured part equals the blood pressure in the vessels. This is a simple mechanical process. The escape of the white corpuscles, on the other hand, is determined and limited by the work they are required to do, and varies as the conditions vary. Their escape through the vessel wall is not due to blood pressure, for why a certain definite pressure should drive out the white corpuscles when it leaves plasma and red corpuscles undisturbed is a query that waits for an explanation. We call the locomotion of the white corpuscle "amœboid movements," but have not yet fully accepted the theory that the execution of amœboid movements necessitates the other qualities of the amœba, *i.e.*, desire for food, ability to find, digest, and assimilate it, etc. From this point of view the travels of the white corpuscle are not mechanical, but we interpret them rather as an evidence of the vital activity of a series of cells which combine to work for a certain definite purpose, and perform their work or die in the attempt.

It is misleading to speak about physiological and pathological diapedesis. The latter represents merely an accelerated activity of the former; they differ from each other in quantity, but not in quality. In physiological conditions the white cells travel constantly from blood and lymph vessels into the surrounding tissues, but the work of these wandering cells is practically unknown, and what little we know is confined to the alimentary tract, where they aid in carrying fat globules into the circulation, travelling backward and forward until the work is done. Diapedesis becomes more active in many of those conditions which are not quite physiological nor quite pathological, such as the smoothing of sharp bony edges or the absorption of different forms of "lumps." Its activity increases rapidly when pathological conditions arise. In the repair of those wounds which we say 'heal by first intention,' the white cells leave the blood-vessels in large numbers, and aid, first, in the coagulation of the blood which unites the edges of the wound; after that they fill the wound completely, and while some provide the necessary nutriment for the connective tissue which is forming, the others find their way back again into the circulation by way of the lymphatics when their services are no longer required. When, however, bacteria or irritants have entered the wound, diapedesis assumes its most intense form. Masses of white corpuscles leave the vessels and, entering the tissues which surround the infection, they pack themselves so close together that they almost form a membrane which separates the healthy from the unhealthy tissues and prevents the infection from spreading. The white corpuscles which die in this struggle are found in the wound as pus corpuscles.

As long as our knowledge of the function of the white blood corpuscle is vague, our exact understanding of diapedesis will be more so, for the latter is determined by the former. As long as we have not even agreed whether the white cells in all their varieties are distinct histological units or different stages of development of a single type, we shall not be able to demonstrate that their activities outside of the vessel walls can be differentiated; and even after we have admitted that there are different kinds, we have still to find out whether one kind carries fats, another repels bacteria, still another absorbs bony edges, etc., etc. Indeed, careful researches into the life history of the white blood corpuscle in the circulation as well as outside of it will unlock many obscure phases of health, immunity, and disease; and as our knowledge advances, a revision of our nomenclature will accompany it.

Julius Pohlman.

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DIAPHORETICS are those drugs and therapeutical agencies which promote perspiration. The name *sudorifics* is etymologically equivalent. As a class of remedies they find no place in the classification in various modern works on therapeutics. Their use in medicine is in full analogy with the natural or physiological process of perspiration.

Bearing in mind, then, the physiology of the skin, its thermotaxis and the functions of its sweat-glands, let us turn our attention to the practical utilization of these data in the treatment of disease. The *indications* for diaphoretics are found:

First, in their antipyretic action, especially in the early stages of specific fevers and acute inflammations of a not very severe type; their action being that of a revulsive in bringing the blood to the surface by the enlargement of the superficial blood-vessels and so relieving internal congestion, and possibly at the same time aiding in the elimination of morbific matter that has been retained in the system. Illustrations are found in acute nasal or bronchial catarrh, in muscular rheumatism, and in suppressed menstruation.

Second, to avail of the vicarious function of the skin in promoting absorption in acute or chronic nephritis with uræmia or suppression of urine. When there is dropsy, jaborandi or its alkaloid is the only medicinal diaphoretic of real value.

Third, to favor the passing off of diseases such as remittent malarial fevers which naturally terminate in a sweating stage.

Fourth, to help in the elimination of noxious materials from the blood, for there is evidence that besides urea in cases of renal diseases, sugar may be so removed in saccharine diabetes, lactic acid in rheumatism, and biliary products in obstructive disease of the bile passages (Wood).

Fifth, to relieve some forms of skin diseases, when the activity of the sweat glands is deficient.

The principal diaphoretics, as grouped by the writer of the article in the Edinburgh "Encyclopædia Medica," are warmth, hot drinks, jaborandi (pilocarpine), liquor ammoniæ acetatis or citratis, potassæ citras, potassæ nitras, ipecac (Dover's powder), opium, antimony (pulvis antimonialis or vinum antimonii), alcohol, salicin and the salicylates, various pungent and aromatic substances when taken into the month." Hare says that the only drugs we know to be direct stimulants to the sweat glands are pilocarpus and Warburg's tincture, which latter is, next to pilocarpus, the most powerful sweat producer we have. It might be considered that the group of drugs of which antipyrine and acetanilid are the well-known types, should properly be included among the diaphoretics, but it must be borne in mind that the chief action which they show is as antipyretics, while the promotion of perspiration, though often very noticeable, is a secondary result and may be checked by such drugs as atropine or agaricine, the fall of temperature meantime continuing (Cushny).

Individual Diaphoretics.—Heat applied externally, either dry or moist, is one of the readiest and most efficient means at our disposal, and its effect may be heightened by the use of hot drinks either mildly alcoholic or containing certain aromatics (ginger tea, hot whiskey punch). Many persons resort to the Russian (moist) or Turkish (dry heat) bath for the relief of attacks of muscular rheumatism, while as a domestic remedy the mustard foot-bath is constantly made use of in the onset of "colds," especially when accompanied by some fever. "The dropsy remaining after the earlier stages of acute nephritis," says Osler, "is best treated by hydrotherapy. In children the wet pack is usually satisfactory, and it is applied by wringing a blanket out of hot water, wrapping the child in it, covering this with a dry blanket, and then with a rubber cloth. In this the child may remain for an hour. It may be repeated daily. In the case of adults the hot-air bath or the vapor bath may be conveniently given by allowing the vapor or air to pass from a funnel beneath the bed clothes, which are raised on a low cradle. More efficient, as a rule, is a hot bath (temperature of 100° F., gradually raised to possibly 110° F.), after which the patient is wrapped in blankets. The sweating produced by these measures is usually profuse, rarely exhausting." It may be remarked that profuse sweating is rarely so exhausting as purging.

Jaborandi (pilocarpus), with its preparations and its alkaloid pilocarpine, stimulates the peripheral ends of the secretory nerves. They represent the most valuable drug of this class, for this diaphoretic may be used with advantage not only in the onset of influenza and in subacute rheumatic attacks, but also in both acute and chronic Bright's disease, in which it is found most efficient in removing the dropsical accumulation and with it the urea which has been held in solution. The effusions of recent pleuritis, hydrothorax, and ascites have been quickly removed by the drug. The fluid extract of pilocarpus may be given in doses of from ♏ xv. to xxx., or even ♏ lx., repeated once a day or once a week as required; while the alkaloid, which is less apt to nauseate, may be given hypodermically in doses of gr. $\frac{1}{20}$–$\frac{1}{2}$. The possibility of danger from its depressing action on the heart should always be borne in mind, especially when this drug is used in dropsy due to heart disease. According to H. C. Wood the effects of the drug may set in in five minutes after a hypodermic injection of pilocarpine and the sweat may amount to from nine to fifteen ounces by estimation. He recommends the following method of administration: "Give a dessertspoonful of a mixture containing pilocarpine muriate gr. $\frac{1}{12}$, antipyrine gr. v., Tinct. aconit. rad. ♏ i.–iij. Soak the feet in a hot mustard bath. Then put the patient to bed and give a teaspoonful of the mixture with a tumbler of hot lemonade or whiskey punch and repeat the pilocarpine mixture every twenty minutes till he sweats." Pilocarpine is much used as an ingredient of lotions to promote the growth of the hair, and its favorable effects may be due to the fact that it increases the action of the glands of the scalp. The following is a successful topical application in alopecia: ℞ Ext. fl. pilocarpi, fl. ℥ i.; Tinct. cantharid., fl. ℥ ss.; Lin. saponis fl. ℥ iiss. M. S.: Rub the scalp well daily. (Bartholow.)

Liquor Ammoniæ Acetatis (Spiritus Mindereri) is of very moderate utility and is little used except as a vehicle or in combination with other drugs such as aconite or ipecac. Nor is it necessary to say more of the *citrate of ammonia*, the *citrate of potassa* in the form of the neutral mixture or effervescing, or of *nitrate of potassa.*

Dover's Powder (Pulv. Ipecac. Compositus), representing in combination the two diaphoretics ipecac and opium, was the best-known and most serviceable diaphoretic drug prior to the introduction of pilocarpus. Its action is partly due to both these ingredients, the opium adding to the effects of the ipecac in dilating the vessels of the skin. Its action is gentler than that of pilocarpine. The dose for an adult is gr. x., or doses of two or more grains may be given at one time and repeated at suitable intervals of one hour or more. It has an established repute for the relief of acute catarrh of the respiratory mucous membranes—and it is efficacious in many other conditions in which an opiate is not contraindicated.

Antimony, in the forms of pulvis antimonialis (James' powder) and of vinum antimonii, was formerly much more used as a diaphoretic than it is to-day. Its action is that of a powerful depressant of the arterial circulation. It has a decided action in causing perspiration when given in doses of gr. $\frac{1}{12}$, but for this purpose it has of late years been superseded by pilocarpine.

Alcohol, in its various combinations in wines and beers and spirits, especially when the latter are drunk with hot water, stimulates the circulation of the skin and dilates the blood-vessels, thus leading to free diaphoresis. It may be used in considerable dilution as an adjuvant to other diaphoretic mixtures, as has been specified above. When taken to excess so that its narcotic effect is manifested, the diaphoresis which accompanies it is due, as in the case of opium and other narcotics, to the increased venosity of the blood.

Guaiacum, of which the best preparations are the simple and ammoniated tinctures, has had some rather questionable reputation as a diaphoretic. It is an ingredient of various anti-rheumatic mixtures, and perhaps the utility of some of them may be measurably due to its action on the skin as an aid to the removal of the morbific elements from the affected tissues. The dose is from fl. ʒ ss. to i. of either tincture. *J. Haven Emerson.*

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DIAPHRAGM. See *Thorax*, and *Cœlom*.

DIAPHRAGM, DISEASES AND INJURIES OF THE. —Since the diaphragm is composed of tendons and muscles and enervated by a nervous apparatus, not materially differing from similar tissues found in other parts of the body, it is subject to the diseases common to such tissues in all parts of the organism. Few of its affections are limited to its own tissues, and frequently its symptoms are merely a part of a general symptom complex which has its origin in a diseased organ more or less remote from the diaphragm.

Displacements and impairment of the movements of the diaphragm may be due to loss of tone and elasticity of the musculo-tendinous structure, but by far the most frequent agent in producing such conditions is a change in the balancing of the intra-thoracic and intra-abdominal pressures. Increased intra-thoracic pressure frequently depresses the diaphragm; this may be unilateral or bilateral. It is produced by tumors of the lung, pleura, or mediastinum, by collections of fluid or gas in the pleura, and by loss of lung elasticity as in pneumonia, emphysema, etc. Increased intra-abdominal pressure often raises the elevation of the diaphragm; this is usually bilateral, rarely unilateral. This may arise from pregnancy, cysts, and tumors of the abdominal viscera, from ascites and inflammatory exudates as in peritonitis, subphrenic abscess, etc., and from accumulations of gas, intra-peritoneal or intra-intestinal. Displacement may be produced by pleuritic, peritoneal, or pericardial adhesions, by a kyphosis of the spine, or by the pull of an enlarged liver. With the change in position there is usually associated a diminution in motion which may be so great as to be entirely lost. In upward displacements there are frequently signs of compression of the lungs at the base; breathing is embarrassed and tends to become costal. Downward displacement is evidenced by a protrusion of the abdominal wall and by the low position of the spleen and liver. Litten's "diaphragm phenomenon" is most useful in determining changes in position and movements of the diaphragm. It is thus described: When "the patient is made to lie on his back, his head but slightly supported, opposite the window to which his head is turned, while at a distance of three or four feet the observer, with his back toward the window, scans his chest at an angle of 45°," the height and movements of the diaphragm are marked on the thoracic wall by a shadowy line, lying at an acute angle to the ribs, denoting its momentary position. The excursion of the shadow under normal conditions should average two and one half inches in forced respiration; less than this shows an abnormally impeded movement. In unilateral changes the contrast of the shadows of the two sides is very evident. The prognosis and treatment depend upon the cause and its removal.

Traumatisms to the diaphragm rarely occur without concurrent injuries to adjacent organs, and the symptom complex afforded by the latter often masks those of the former. Blows and falls causing rupture or strain of the musculo-tendinous tissue may occur without evidence of injury to the external parts. Rupture is frequently the result of blows and wounds to the lower chest, stab wounds intended for the heart and fractured ribs being especially in evidence. Men, as they are especially exposed to trauma, are more commonly the subjects of this lesion. On account of loss of elasticity of muscle the aged are more liable to rupture. The left is the side most frequently affected, probably because wounds are more frequently directed toward this side, and the liver, on the right side, prevents the development of complications calling attention to the injury to the diaphragm. The symptoms of diaphragmatic injury are usually secondary in importance to those of other organs coincidently injured. There is considerable shock, at times passing into collapse. The face is drawn (risus sardonicus), nose pinched. The respiration is embarrassed and there is pain at the site of diaphragmatic attachment. Not infrequently there is a resulting hernia. The diagnosis is often overlooked in considering the trauma to other organs. The prognosis is usually grave. Treatment is as a rule necessarily first directed to the coincident injuries to adjacent organs and to meeting shock by the usual methods. The edges of the wound may be closed either by suture to each other or, as in a case reported by Frey, by suturing one edge also to the chest wall. It should be borne in mind that hemorrhage from a wound of the chest may be from the diaphragm as well as from the lung and the thoracic wall.

Hernia.—Herniæ of the diaphragm are not very rare. Leichtenstein has collected 252 cases and Lacher 276 cases. By hernia is understood any escape of the organs, normally lying below the diaphragm, through the diaphragm into the chest cavity, whether the escaped organs are enclosed in a true hernial sac or not. In 276 cases there was a sac in 28 instances, and of these 25 were congenital herniæ. Herniæ may be either congenital or acquired; of 267 cases 117 were congenital.

Congenital Herniæ are due to an arrest of fœtal development and occur usually on the left side, since congenital defects of the diaphragm are more frequent on the left side, and the muscle congenitally deficient is protected on the right side by the liver. In 117 congenital cases Lacher found 98 of the left side against 19 of the right. The opening is more frequently in the muscular than in the tendinous structure, and more often in its posterior portion. The size of the aperture varies from a small hole to one involving one-half of the diaphragm. Often these defects of the diaphragm are associated with other congenital defects (hemicrania, anencephalia, defective fingers, toes, etc.). These cases are at times stillborn or at best they live a few hours, although there are rare cases on record of the patient's reaching maturity and even old age. Living babies suffering from this condition are very cyanotic, and after a longer or shorter period of labored breathing reach the fatal termination. If the diagnosis is made the little patient may be held erect in the hope that gravity may assist in bringing about a reduction of the hernia; water pressure by rectal injection has been advocated. No case of operative interference is on record.

Acquired Herniæ are usually the result of a traumatic rupture of the diaphragm, but there are also records of rare cases of hernia through a weak point in the diaphragm (sometimes coincident with one of the natural openings, *e.g.*, the aperture for the œsophagus), following the excessive intra-abdominal pressure of labor, vomiting, and the like. They are mostly found in men, who are more liable to injury than women. In looking over the literature I have found only one case following pathological perforation. Lacher reports 150 cases following traumatism; the hernia occurred on the left side in 127 cases, only 3 cases being provided with a sac. The greater frequency of left-sided hernia is explained by the greater number of injuries to the left side of the chest and the absence of protection by the liver. Through the ruptured or defective diaphragm any of the abdominal organs may find their way into the chest cavity. The following is a list of the organs (in order of frequency) thus found displaced: stomach, omentum, colon, small intestine, liver, duodenum, pancreas, cæcum, and kidney. If the opening in the diaphragm has existed for any considerable period the edge is found smooth, thickened, and rounded. Adhesions between the displaced organs and between these and the diaphragm are of exceedingly rare occurrence. An organ at one time a part of the hernial protrusion may find its way back to its normal abdominal position, thus materially affecting the clinical picture.

In traumatic hernia, injuries to other organs may completely mask the symptoms of the hernia proper, but as the early symptoms pass away the evidences of the hernia usually make themselves apparent. The physical signs vary considerably according to the viscus which is displaced, its volume, and its position. The lower chest appears full, the abdomen hollow; respiration is costal, the respiratory movements of the abdominal wall being absent or greatly reduced. Litten's "diaphragm phenomenon" indicates movements diminished, absent, or unequal on the two sides. Dyspnœa is usually an early and prominent symptom. Palpation shows diminished movements of the liver, spleen, and stomach in inspiration, or a displacement of these organs from their normal position. The heart is frequently displaced, usually backward and to the right. The hand placed on the chest may often detect the movements of the displaced intestine. Percussion shows a compressed or collapsed lung replaced by signs of a viscus solid or containing fluid or gas. By auscultation, in addition to the change in the lung and the embarrassed condition of the heart, one may hear the movements of the stomach and intestines and the splashing of their contents within the chest, often with succussion and metallic tinkle, while the deglutition sounds may show a wide variation from the normal. Abnormal friction sounds may be present. Subjective symptoms are liable to extreme variations with the change in the volume and the position of the hernia. The dyspnœa may be continuous or paroxysmal and attended by extreme cyanosis. The pain may be considerable and is increased by movement; it is usually referred to the site of the attachment of the diaphragm to the body wall. Cough, hiccough, and vague gastric disturbances may exist. If strangulation of the bowel supervenes, the symptoms of acute intestinal obstruction may be added to the picture.

A number of cases are on record in which the hernia existed for years, some with very mild and others with severe symptoms, only to be revealed on autopsy. One patient lived fifty-two years after the occurrence of the hernia. Doubtless many patients recover without a discovery of the lesion. In general, however, the prognosis is bad. In 33 cases following stab wounds there was a mortality of 88 per cent. It should be borne in mind that the gravity is greatly augmented by trauma to some of the organs involved and the resulting complications, prominent among which are perforation of the stomach and empyema. Strangulation is always to be dreaded, and may occur years after the original injury, being induced by some unusual effort, as an attack of vomiting, coughing, straining, etc. Death from strangulation of the stomach or intestines occurs, according to Leichtenstein, in fifteen per cent. of the cases. Another frequent cause of death is the compression of the lungs and heart by the distention of the displaced viscera by gas or the sudden passage of additional organs through the hernial opening.

Diagnosis.—That the diagnosis is difficult may be inferred from the fact that in a collection of 300 cases only 7 were diagnosed during life. Among the more important diagnostic points may be mentioned: fulness in the chest associated with a hollowed abdomen, evidence of movements of the intestine and its contents in the chest, and the displacement of the heart. Hernia is most often mistaken for pneumothorax. The latter usually occupies the entire half of the thorax, is about equally frequent on both sides of the chest, is absorbed gradually; the physical signs are fairly constant, and there is frequently an antecedent history of disease of the lung or pleura. Hernia usually occurs on the left side, occupies an irregular portion of the thorax; its volume and position change from day to day, affording great variation in physical signs, and the subjective symptoms are subject to greater variation.

On account of the frequency with which hernia results from stab wounds of the lower chest, Paget recommends that every such wound should be thoroughly explored as soon as it comes under observation so as to exclude positively every case of hernia.

Treatment.—All adjacent organs should be carefully examined and their injuries cared for. The reduction of the hernia can be accomplished much more easily from the chest cavity than from the abdomen, and since the diaphragm is also far more accessible from above, the avenue of approach should be through the chest wall. Access should be obtained by resecting several ribs, thus allowing a large flap of chest wall to be raised. The prolapsed organs, after being cared for, are reduced and the diaphragm closed by strong sutures; the reduction may necessitate an increase in the size of the diaphragmatic opening. Through such an opening it has been possible to close a perforation of the stomach and cleanse a large portion of the viscera, the case resulting in recovery. The chest wall is replaced, a sufficient opening being left to permit of a small drain reaching to the site of injury. Successful cases which have been operated on are reported by Posternski, Llobet, Dalton, Humbert, Mikulicz, and others.

DIAPHRAGMITIS.—Primary inflammation of the diaphragm is an extremely rare condition and its existence is denied by several writers. Primary localized inflammation of its serous coverings is not uncommon. Waldeyer has reported a case of diaphragmitis following puerperal sepsis in which the lymphatics of the diaphragm were swarming with micro-organisms. The process may result in a fatty degeneration of the muscle fibres. There are usually a sense of constriction in the epigastrium; pain at the line of insertion of the muscle, increased by pressure on the epigastrium and by the movements of respiration; embarrassed breathing, cough, singultus, and fever. A differentiation between this and localized pleurisy or peritonitis is difficult and is rarely made during life. Treatment consists of rest and the administration of morphine for the pain.

PERFORATION.—Perforation is produced by a localized suppurative process, usually by the burrowing of pus upward or downward, and by the extension of neoplasms. The common etiological factors are empyema, purulent pericarditis, suppurative hepatitis, subphrenic abscess, and perforating ulcer of the stomach. In 28 cases of ulcer of the stomach causing perforation of the diaphragm, 20 were found to have produced this directly, and in only 8 was a subphrenic abscess formed before the perforation. Treatment should be directed to the underlying cause.

ADHESIONS.—Adhesions between the diaphragm and neighboring organs (either thoracic or abdominal) are of common occurrence. They are usually the result of the inflammation of the pleura or peritoneum of this region, and are commonly elastic bands which are occasionally infiltrated with calcareous material and do not hold the adjacent organs very closely or firmly together. When adhesions exist between the diaphragm and the pericardium, there is pulsation visible in the epigastrium. Other adhesions may cause displacement or impede the movements of the diaphragm.

RHEUMATISM.—Rheumatism may attack both the muscular and the aponeurotic structures of the diaphragm. It may be acute or chronic; the acute form may be idiopathic or may be secondary to rheumatism in other parts of the body. The attack comes on suddenly, usually after exposure to damp and cold with chilling of the body surface. There are systemic symptoms only when this is a part of a general rheumatic affection. Pain at the line of attachment of the muscle to the body wall is severe and is increased by movements and pressure; it may often be marked out by palpation; only rarely is it unilateral. Food passing the œsophageal opening may cause distress. Pain embarrasses the movements of the diaphragm and respiration becomes costal. There may be tonic or clonic spasm of the diaphragm with hiccough, also spasms of the œsophagus and larynx. The diagnosis is sometimes difficult. The conditions most frequently confounded with it are pleurisy, intercostal neuralgia, asthma, and angina pectoris. Rheumatism in other parts of the body, the absence of pleuritic râles, and the location of the pain will aid in establishing a diagnosis. The prognosis is nearly always good. Anti-rheumatic treatment affords the most satisfactory results, notably the administration of the salicylates with alkalies. Physiological rest is important and may be assisted by strapping the lower chest with broad strips of adhesive plaster. Locally cupping and painting with tincture of iodine are of service. Morphine may be necessary to relieve the pain.

Neoplasms.—Neoplasms of the diaphragm are secondary to growths in adjacent parts. The diagnosis is made during life only in extremely rare cases; they are in the main post-mortem curiosities. Grancher has reported one case of primary new growth. The forms met include cancer, tuberculosis, hydatid cysts, and calcareous deposits associated with muscle degeneration (Otto). This seems to be frequently produced by a long-existing pleurisy. Perforation of the diaphragm has occasionally been produced by neoplasms.

Nervous Affections.—The affections of the diaphragm due to a traumatic or diseased condition of its nerve supply may be considered under the headings of neuralgias, spasms, paralyses, and atrophies. As the phrenic nerves convey by far the most important nerve impulses to and from this organ, the changes in this nerve and in its centres in the spinal cord include the major portion of such affections, while changes in the intercostal nerves may be practically disregarded in this connection.

Neuralgias are not uncommon affections, their etiology being much the same as that of neuralgias of other nerve areas; a sudden chilling of the body, nutritional disturbances as in anæmia and rheumatic affections, and inflammatory processes in adjacent organs, such as pleurisy and pericarditis, may be mentioned as especially prominent. Pain, usually severe, at the line of attachment of the diaphragm to the chest wall, sometimes radiating to the shoulder, is always present. The pain may follow the course of the phrenic nerve in the neck. The pain often interferes with respiration. There may be dysphagia. Diaphragmatic neuralgia is often confounded with angina pectoris, pericarditis, and pleurisy. The treatment consists in removing the general causal condition, in the local application of revulsives, and in the hypodermatic use of morphine, antipyrin, etc.

Spasm of the diaphragm is rare, excepting when it is secondary to some general disease, which is usually a neurosis. Spasms may be tonic or clonic, the latter being far more common and less serious than the former. While rare cases of idiopathic *tonic spasms* have been described by Duchenne and others, by far the greater number are symptomatic and are merely developed in the course of some general disease. Of these may be mentioned epilepsy, asthma, eclampsia, rabies, tetanus, and strychnine poisoning. The spasms may be short or may continue for a considerable period, the respiration is altered to the costal type, the thorax is enlarged at the base, and the liver is pushed down. There are attacks of dyspnœa and a feeling of suffocation with pain encircling the body like a girdle. As the suffocation verges on asphyxia all the accessory muscles of respiration are brought into play. There is a diminished vesicular murmur over the lower part of the lungs. If the spasm is short, the patient soon resumes normal breathing; if long, he dies with the agonies of asphyxia. To relieve the condition, energetic counter-irritation should be applied to the thoracic walls, epigastrium, and lumbar regions, the actual cautery, hot compresses, and wet or dry cups being especially serviceable. The faradic brush, applied along the line of attachment of the diaphragm, has also accomplished good results. As anti-spasmodics one may employ chloroform, ether, valerian, the bromides, and the nitrites.

Clonic Spasm of the diaphragm occurs far more frequently than the tonic; there is no idiopathic type, and it occurs only as a symptom of some causal disease. The subjects of such a spasm are usually of a neurotic temperament. The main etiological condition is an irritation of the respiratory centres. This may be functional, as in hysteria and epilepsy; it may follow a central or spinal lesion or poisoning, as in typhoid, septicæmia, uræmia, etc.; or it may be the result of reflex irritation from a peripheral source, *e.g.*, stricture of the œsophagus, intestinal and gastric affections, overloading of the stomach, peritonitis, disorders of the pleura, pericardium, liver, bladder, uterus, etc. The contractions of the muscular apparatus vary extremely in force and frequency. From one a minute they may, as in some observed cases, increase to one hundred a minute when the successive movements form a continuous tremor. The diaphragm strikes violently against adjacent viscera and pushes them about. With each inspiration the whole abdomen is raised and there is often a peculiar succussion sound. In the common form the ordinary hiccough is the most evident manifestation; so common is it that many writers consider it synonymous with clonic spasm of the diaphragm. Speech is interrupted and inarticulate noises accompany each spasmodic movement. A small group of these cases occurring in patients of a neurotic disposition may be considered true spasmodic tics. There is the quick, convulsive movement of the diaphragm followed by an explosive expulsion of the breath, with a harsh rasping noise. When the patient is noticed or becomes excited the spasms increase in frequency. If these spasms pass away quickly the patient soon regains his normal status; but if they are long-continued (cases lasting several weeks are on record), the patient becomes exhausted with the movements and consequent loss of sleep.

The prognosis depends on the cause and the duration of the attack. It is not as dangerous as the tonic spasm, but may seriously interfere with the ingestion and assimilation of food. Of the tics it is said they "rarely shorten life." The prognosis is bad in adults, but good in children if the affection is taken in hand early. Treatment should be directed to the cause, which should be removed, if possible; general tonics, moral control, with rest and massage, have their place. As symptomatic treatment innumerable methods have many zealous advocates. Among these are: holding the breath for long periods, pressure over the phrenics in the neck, pressure or ethyl chloride spray on epigastrium, galvanism and faradism (one pole over each phrenic, or one over phrenic and one at diaphragm), and the administration of atropine, hyoscine, anæsthetics, nitrites, and morphine.

Paralysis of the diaphragm may follow injuries, inflammations, or pressure on the phrenic nerve. The common site of injury to the phrenic nerve is in the neck, where its protection is less than in other parts of its course. A neuritis involving the phrenic may follow diphtheria, beriberi, influenza, rheumatism, and poisoning by lead, alcohol, coal-tar products, etc.; or it may be a direct extension from neighboring inflamed organs as in pleurisy. Pressure may be the result of tumors of the neck or mediastinum. Paralysis of the diaphragm also occurs with pathological processes of or injuries to the upper cervical segments of the spinal cord. Among the pathological processes may be mentioned tumors, hemorrhages, tuberculous or other chronic inflammatory affections, as amyotrophic sclerosis, bulbar palsy, ascending myelitis, and progressive muscular atrophy. Paralysis also occurs in hysteria and with inflammations of the lungs and pleura; in the latter the movements of the diaphragm are inhibited by the reflex pain. The loss of diaphragmatic function may be unilateral or bilateral, and again it may be complete or partial. In complete bilateral paralysis the breathing is costal and may be easy while the patient is at rest, but the least exertion induces marked dyspnœa; there is a feeble voice, embarrassed by inspiration, or complete aphonia. Palpation fails to reveal descent of the diaphragm, and the abdominal wall sinks in inspiration and bulges in expiration. Litten's sign is absent. There is loss of vesicular murmur over the base of the lungs and the fixing of the diaphragm for coughing, straining at stools, etc., becomes impossible. When the paralysis is unilateral, the loss of function on one side may be so compensated by the movements of the other that the paralysis is not evident. If the patient is directed to take deep inspirations, the difference between the two sides will show plainly; furthermore, in this condition the contrast between the two sides, as shown by the Litten's diaphragm shadow, is particularly marked. Following the defective respiration bronchitis often develops in the lower lobes, and the exudate is coughed up with the greatest difficulty. The diagnosis is at times easy, at other times extremely difficult; the changes in the respiratory movements, the loss of Litten's diaphragm phenomenon, the aphonia, and the weakening of the vesicular murmur are important points in differentiating this from other affections. The prognosis, while favorable in rheumatism and hysteria, is extremely grave when the paralysis arises from other causes. It varies according to the extent of muscle involved. If the paralysis is complete, a fatal asphyxia may come with the slightest exertion; this is the final termination of many diseases instanced above as among the causes of paralysis. Treatment should be directed primarily to the underlying cause. Locally electricity has proved of great value, in some cases faradism and in others galvanism being found most efficacious. One pole should be placed over the phrenic nerve in the neck, the other over the abdomen just below the diaphragm. A current passed transversely through the diaphragm has also been found to work satisfactorily.

Atrophy of the muscle of the diaphragm may occur in any of the general diseases which cause muscular atrophy in other parts of the body. It occurs as a result of the destruction of its motor nuclei in the spinal cord (in spinal progressive muscular atrophy), as a result of a peripheral neuritis involving the phrenic nerve, and as a myopathic condition (in pseudo-hypertrophic muscular paralysis and idiopathic muscular atrophy). The symptoms depend on the weakness following the muscular atrophy, which ultimately results in complete paralysis. It has been discovered post mortem in patients dying of bronchitis, emphysema, interstitial pneumonia, and pericarditis. The dyspnœa and asphyxia, of which it is the cause, are frequently the closing features of the diseases above enumerated. The prognosis is bad. Treatment has been of small avail. When the spinal disease is of syphilitic origin, mercury and potassium iodide may arrest the disease. For the atrophy of myopathic origin, arsenic, nitrate of strychnine, and galvanism have been recommended.

Subphrenic Abscess.—Subphrenic abscess is not a rare condition, although it is only in comparatively recent years that this name has been applied to localized collections of pus having the under side of the diaphragm as one of its boundaries. The etiology of this lesion comprises two factors: a source of bacterial infection and a localizing agent. It may be a part of a general infection as in pyæmia, septicæmia, or tuberculosis. Trauma may act as the localizing agent, while infection may travel by metastasis from a distant infected area, by means of the lymphatics so abundant in this region, or by direct invasions from neighboring organs. Prominent among these are ulceration of the stomach, duodenum, and colon, appendicitis, abscess of the liver, suppurating echinococcus cysts, perforation of the gall bladder and bile ducts, and empyema. In an exhaustive monograph Maydl reports 179 cases with the following classified sources of infection: Stomach and duodenum, 35; cæcum and appendix, 25; liver and bile passages, 20; internal injuries, 18; hydatid disease, 17; intestines, 13; metastasis, 11; inflammation about the kidney, 11; interior of chest, 9, external, 6; caries of ribs, 3; miscellaneous, 11.

A classification of subphrenic abscesses naturally arranges them as intra- or extra-peritoneal; the latter occur far more frequently on the right side. Since the falciform ligament forms a natural barrier, the abscesses are usually confined to one side. Those of the right side occupy the space between the diaphragm and the liver; those of the left have the diaphragm above and posteriorly, and for their other boundaries some part or all of the following organs, which are commonly matted together by adhesions: stomach, spleen, transverse colon, and the left lobe of the liver. Any one of these may have been the chief causal factor as a starting-point for the infection. The abscess may often be considered as a localized encysted peritonitis; it may vary in size from that of an egg to a cavity holding over two litres. The edges are, as a rule, rough and lined with fibrinous pouches; a few have smooth walls. The contents may be pus alone or pus and gas. The pus may be thick and devoid of odor, or ichorous, mixed with necrotic tissue, putrid and fœtid, and colored by the pigments of bile or blood. Gas may come from a primary opening, from an organ containing gas, from a secondary opening formed by the abscess breaking into such an organ, or from gas-forming bacteria. Of Maydl's 179 cases 47 contained gas; of these, 20 came from primary perforations from the alimentary tract, 18 from secondary perforations (16 into lung and 2 into alimentary tract), and 9 from gas-forming bacteria, no perforation being present. Among the micro-organisms found the Bacillus tuberculosis, Micrococcus tetragenes, staphylococci, and the Bacillus coli communis have been isolated. Osler considers the finding of Bacillus coli communis helpful in proving the alimentary tract as the source of infection. The diaphragm is pushed up and is frequently adherent to the lower ribs. Pleurisy and pericarditis, serous or purulent, may exist as cause or effect. The abscess, if left to itself, most commonly perforates the diaphragm, infecting the pleural cavity and the lung. The destructive process may reach the bronchi, which may afford sufficient drainage for complete evacuation and spontaneous cure. Other paths of exit are through the abdominal wall and into some part of the alimentary canal.

The clinical features of subphrenic abscess are greatly modified by the associated lesions and may accordingly have extreme variations. While at times the respiratory functions are so modified as to make this aspect the most prominent, it is more usual for the symptom complex to suggest an abdominal lesion. The symptoms may be obscure and develop slowly, or, as in cases due to the perforation of a gastric ulcer, they may be very evident and may accumulate with extreme rapidity. There is usually considerable pain in the hypochondriac or epigastric region, often radiating to the shoulder, with or without tenderness. The pressure on the diaphragm and the pain embarrass respiration, making it short and superficial in character, with more or less dyspnœa. The inflammation of the peritoneum is evidenced by meteorism, vomiting, hiccough, and general depression, with rapid, weak pulse. There may be signs of a general pyæmic infection, with rigors, fever, and sweating. The abscess may cause a bulging of the upper abdomen or lower part of the chest, with superficial heat and redness associated with nature's attempt to form an exit externally. The region in which these abscesses commonly point is near the ensiform cartilage. The ribs may be displaced, lying more horizontally than normal, and separated by broader intercostal spaces. Palpation may show fluctuation when the collection of pus is superficially placed, friction from the surrounding peritonitic exudate, a liver or spleen displaced downward, and, when the abscess cavity is partially filled with gas, succussion. Percussion elicits dulness over the lower part of the chest and upper abdomen continuous with that of the liver or spleen, or, if gas is present, amphoric and metallic resonance and obliteration of normal hepatic or splenic dulness. Amphoric breathing, splashing, and metallic tinkling may frequently be heard, closely simulating the signs of a pyopneumothorax. The clinical picture may vary from day to day as in cases in which the abscess cavity, originally filled with pus, is additionally distended with gas. Perforation of the diaphragm, with its resulting empyema, rupture into the lung, and evacuation of the cavity through a bronchus, are features not infrequently added. If the abdominal adhesions are broken down a fatal peritonitis rapidly follows. The condition lasts for from fifteen days to several months, and is usually fatal unless relieved by operative interference. In a number of cases evacuation may take place through a rupture into a bronchus, into some portion of the alimentary tract, or externally, the latter being an extremely rare occurrence. Death results from general sepsis, empyema, rupture of pericardium, or abscess of the lung, or from peritonitis. This condition is frequently difficult to diagnosticate from empyema and pyopneumothorax.

The exploratory needle may assist in locating the cavity, but it should only be used when means are at hand to operate for the relief of the condition, on account of the danger of serious extension of the infection along the path of the needle. If a cannula be thrust into the abscess, its contents are expelled in inspiration more forcibly than in expiration—contrary to that which occurs when the pus is above the diaphragm (Pfuhl). This sign may be absent when the diaphragm is paralyzed as a result of long existing inflammation, or if the diaphragm and lung are perforated. In subphrenic abscess the upper line of dulness usually follows the convex curve of the diaphragm, and the lateral line of dulness runs from before backward and from above downward, quite contrary to the usual outlines of an empyema. In pyopneumothorax there is usually an antecedent history of disease of the lung, the whole chest is enlarged, vesicular murmur is entirely lost, and the heart is displaced laterally, while in subphrenic abscess with gas, the chest is enlarged only in its lower portion, vesicular murmur continues over the upper portion of the chest, and the displacement of the heart is upward.

Surgical interference is the only treatment which promises a successful outcome. Opening and drainage are indicated as soon as the diagnosis is made, it being contraindicated only when a natural opening with efficient drainage has been established. An early operation often prevents that serious complication, perforation of the diaphragm, with its attendant dangers. The site for the incision is chosen by the physical signs and the exploratory puncture; the abdominal route and entrance by means of a resected rib have been about equally employed. If the abscess is situated high up, one or more ribs should be resected, the pleura raised and closed off by a line of sutures, and then the abscess should be opened by an incision through the diaphragm. The abdominal route avoids injury to the diaphragm. The general peritoneal cavity is usually well walled off by adhesions. The subsequent treatment consists of irrigation or dry dressings, according to the demands of the individual case. Uncomplicated subphrenic abscesses heal in from sixteen to twenty-four days after their evacuation by incision (Maydl). Of 76 cases operated upon, 39 recovered. Failure after operation is usually due to pre-existing complications.

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DIARRHŒA.—This is a general designation for a class of symptoms among the most formidable of all the manifestations of sickness. It means the occurrence of evacuations from the bowels, either unusually often or abnormally fluid in character. The term is also used to designate certain pathological states of the intestines, which induce or are supposed to induce it; but it is not applied to such diseases as dysentery and cholera, except to characterize a symptom.

In describing diarrhœa, it is customary to divide it into two forms, the acute and the chronic; but the terms are arbitrary, as the disorder varies in duration, from the brief moment of a solitary passage to a continuous stretch of many years. The line is usually drawn, however, at the limit of a few weeks; cases continuing longer are chronic, those of shorter duration are acute. In degree of severity, diarrhœa presents all shades of variations. It arises under a great variety of circumstances, and in conjunction with many different diseases. Nor is this surprising when we consider the extensive mucous surface of the alimentary canal, the indispensable functions of the organs which compose it, and the manifold influences on which they depend, and by which they are disturbed. The wonder is rather that diarrhœa is not more varied and frequent than it is.

The occurrence of diarrhœa is made possible by increased irritability of the bowels—inflammatory, catarrhal, or otherwise—whereby they become intolerant of the presence of their contents, and expel them with abnormal force and frequency, or by the presence of abnormal and irritating substances that provoke the intestine to expel them with undue haste. And, since this intolerance may be caused by many different pathological states of various degrees, and the irritating influences are numerous, and since various incidental events also may ensue from the conditions named, diarrhœa has multifarious forms and varies greatly in its symptomatic behavior.

SYMPTOMS.—The discharges are nearly always more or less fluid. Frequently at the beginning of an attack only normal fæcal matter is voided, but soon the passages become loose and continue so to the end, their character changing as the disorder progresses. Sometimes during a seizure little besides fæcal matter is passed, this being made semi-fluid by the admixture of serum and mucus. Occasionally, and more often in chronic than in acute cases, the fæcal matter appears in scybalous masses, often hard, and sometimes dark-colored and mingled with semi-fluid, slimy, mucoid, or puriform material. In such cases the scybala rarely appear in every passage, but only occasionally, while the fluid material originating in the lower colon and rectum may be passed at short intervals.

The stools present every degree of fluidity, from that of water to thin paste. They may be frothy, or mucilaginous in any degree, from that of slippery-elm water to a slimy mass of trembling jelly. *Mucus*, next to watery serum, is the most common and constant admixture with the fæces in diarrhœa. *Food*, undigested, partially digested, and variously changed, is found at times in the dejections. Most common are the skins and seeds of fruits and vegetables, as apples, cucumbers, and pickles, but articles of food of easy digestibility may be unexpectedly passed. Thus, tender meats and well-cooked and finely comminuted vegetables are found in the passages of both children and adults in diarrhœa, while curds of milk, often green in color, are common in the passages of infants. Certain persons are unable to digest particular articles of a usual diet, and invariably void such undigested. Meat is sometimes voided in a half-digested state, bearing some resemblance to dead intestinal worms, for which it is occasionally mistaken. *Blood* often appears in the dejections of diarrhœa. It may be either fluid or in clots, bright red or dark and venous, chocolate-colored or even black, from long residence or wide journeying in the intestinal canal. It may streak the discharges, be mixed intimately with them, or appear independently. *Pus* is accidentally passed with the stools, either in small quantity and mixed with mucus, or, less often, in large amount and nearly pure. *Fat* forms a part of the dejections in many diarrhœas, although usually it would not be discovered by a casual inspection. *Membranes* and pseudo-membranes are sometimes voided in diarrhœa. False membranes of various sizes and shapes are exfoliated, even at times strips a foot or two in length, while shreds of the superficial layer of the mucous membrane itself may be cast off. Shreds of undigested meat found in the discharges are sometimes mistaken for membrane. *Foreign bodies* of unexpected character often appear in the dejections of acute diarrhœa, especially in children—for example, strings, sticks, pins, pieces of leather, and small coins. In *color* the passages vary. Usually yellow, they may have various shades of red, brown, chocolate color, black or blackish and green, or be opalescent, like milky water.

Flatulence is a more or less common symptom in diarrhœa, and the flatus may be odorless or fetid.

In severe diarrhœa the appearance of the patient always betokens illness. The countenance becomes haggard and shrunken if the attack is continued or severe, general weakness and mental despondency may ensue, loss of appetite usually takes place, although, for a brief period in certain cases, and continuously in others, the very opposite may obtain.

In diarrhœa unattended by inflammation *fever* is a rare symptom; it does not occur in all the inflammatory forms, and does occur to a high degree even in some acute attacks without inflammation. Usually in adults—less often in children—in the acute attacks fever is absent, and the temperature may be subnormal, the surface and extremities particularly being cold and possibly moist with perspiration. *Pain* is seldom wholly absent; it is often experienced in the back, and in bad cases with large, watery stools, painful cramps may occur in the muscles, chiefly of the lower extremities. The pain in the bowels occurs in different localities in the abdomen, and assumes many different forms and relations to the act of defecation. It is seldom constant, usually interrupted, and recurs at varying intervals, often as a colicky suffering, and may be quite independent of an evacuation. Audible evidence of movements of gas in the intestines may mark the recurrences of pain. In relation to the movements of the bowels the pain may occur (1) before a movement, the time before varying from a moment to half an hour, the longer the period the higher in the intestinal tract the seat of pain. The pain may occur (2) at the time of the evacuation, being usually in the rectum and anus, or (3) after the passage, being located in the anus, rectum, or descending colon, and in tissues deeper than the mucous membrane. It may persist for from a few minutes to half an hour after the passage. Pain may be present only in the anus, and that of a burning, scalding character, and mostly after a number of watery passages. The suffering exists during and immediately after an evacuation, and is confined to the mucous membrane of the anus, the cause being mainly the irritating character of the stools, but partly the rough use of improper closet paper or worse substitutes for it.

The abdomen is occasionally tender, particularly over the colon, or throughout, and the patient may bend the body forward in walking or moving, to avoid aggravation of the suffering, or in the recumbent posture the thighs and legs may be flexed to the same end.

Tympanites may be present in varying degree, depending on the extent of inflammatory action and of nervous involvement. Pain may occur in the bladder, in the back, deep in the sacral region, and in the thighs and legs. There may be tenesmus, an involuntary and irresistible straining at stool, with pain in the rectum if this part is particularly involved. Faintness, nausea, vertigo, or a sense of great prostration, or all together, may occur in diarrhœa, and perspiration, more or less profuse, may break forth at the time of an evacuation in an attack of only moderate severity. These symptoms differ according to personal idiosyncrasy and degree of involvement of the tissues of the intestines.

Varieties of Diarrhœa.—The most frequent form of diarrhœa is that which occurs in connection with *indigestion*, which itself has many shapes and symptoms. Occurring suddenly after over-eating it may be associated with vomiting (cholera morbus). One or more free, feculent evacuations are followed by a number that are semifluid, and finally by mucous or watery ones. Diarrhœa occurs after partaking of certain articles of food or drink that, for the occasion, at least, if not habitually, are indigestible or disturbing to the bowels. What affects one person may not another, and one is made sick to-day by what he may to-morrow take with impunity. From eating large-seeded berries, salads, nuts, cheese, fruits, and vegetables, drinking beer, and even milk, certain persons experience diarrhœa occasionally or invariably. Eating in a hurry may cause certain foods, usually easily digested, to disagree and bring on diarrhœa. There is a diarrhœa of indigestion in which several loose passages follow one after the other in rapid succession during the morning and then none again, or at most only one or two, till the succeeding morning—this being repeated daily, sometimes for months. The intestinal canal in a condition of atony or catarrh, or nervous irritability, or all, and wearied by undigested food and irritating substances, expels them and is quiet; the morning diarrhœa evacuates the noxious refuse of the meals of the previous day and the disturbed organs rest. In temporary debility from any cause, diarrhœa from indigestion may come on without dietetic irregularities; it may assume the form just described, or some other. The patient is suddenly liable to derangements of the bowels. In persons nervously sensitive, diarrhœa, with possibly sick headache, may arise from indigestion incident to sudden strong emotion. The experience rarely exceeds one or two loose passages, unless the emotional shock is often repeated, when the diarrhœa may become chronic.

Cholera morbus, so called, is still another form of diarrhœa. It occurs most often after some days of biliousness, mental dulness, headache, and coated tongue. Sometimes the attack is precipitated by a final error in diet, a chill or an emotion; sometimes it occurs without any discoverable exciting cause. It is usually brief, lasting only a few hours or a day, its force being spent by a free evacuation of the bowels. As in other sudden diarrhœas, the first passages are feculent, and the later ones, if the seizure is prolonged, are watery and mucoid. Vomiting may or may not attend the diarrhœa. Bad cases are more prolonged and severe, and may even reach a fatal termination. In such, the dejections, after the bowel is once evacuated of fæcal matter, are copious, watery, and odorless; cramps and collapse take place; there is a rapid and appalling shrinking of the tissues; the eyes sink in; the extremities become cold, and even the temperature of the body is lowered; and finally there are cold perspiration and huskiness of the voice, as in Asiatic cholera. This form of diarrhœa in infants is true *cholera infantum*, a term often improperly applied to slowly progressing catarrhal inflammation of the colon and ileum. Choleriform diarrhœa, in the absence of an epidemic, is usually recovered from promptly by vigorous adults; less promptly by infants, children, weakly and aged people. Diarrhœa may follow *chill* of the surface of the body, with or without other influences. This occurs most often on the approach of cold weather, when people are insufficiently clad, and internal congestions are easily induced. The attacks are sometimes severe; a catarrh of the colon follows the first passive congestion; blood (bloody flux) and much mucus are voided with tenesmus. Diarrhœa in *epidemic form* appears occasionally when it is quite impossible to discover any adequate cause for it. Such epidemics may be general within circumscribed limits, visiting all ages and conditions of life, and may appear suddenly, and, after a few days, as suddenly disappear. Nearly all forms of diarrhœa may characterize such epidemics, but the cases are rarely fatal. The so-called winter cholera, which has prevailed in the winter season in several Northern cities, is an example of this form of diarrhœa. Another form is that associated with some disturbing *emotion*, and which occurs without the additional etiological element of indigestion. Fright, fear, timidity, bashfulness, and suspense are capable of causing sudden diarrhœa. Sometimes, however, they induce the opposite condition of constipation. In either case the phenomenon is a purely nervous one. The diarrhœa of emotion is usually trivial and brief, but in states of prolonged mental and emotional excitement the looseness may be chronic. There are other forms of nervous diarrhœa. Some persons with sensitive abdominal nervous organizations must run to stool immediately after eating or drinking. This trouble is to some extent imaginary—the desire can usually be resisted. But in other cases there is a nervous hyperperistalsis that results in diarrhœa, and prevents either efficient digestion or absorption. Cases of this kind are liable to be persistent, recurring many times, and from the most trivial causes, but always chiefly from those that affect the nervous system, and at times of nervous perturbations. In some persons, this form of diarrhœa is substantially constant and persists for years.

Cathartic medicines produce diarrhœa in one of three ways or by a combination of them: either by increasing the fluid contents of the intestines, or by increasing the peristalsis without irritation, or by irritation of the mucous membrane. Severe catharsis produces pain, tenesmus, and a catarrh of the intestines which prolongs the diarrhœa sometimes for a number of days, the dejections being watery and mucoid; but moderate catharsis, especially after a period of constipation or biliousness, is followed by buoyancy of spirits and a sense of refreshment.

Diarrhœa, with or without vomiting, occasionally occurs from the poisonous action of certain articles of *food* (see *Food Poisons*, and *Ptomaïns*) usually bland and harmless, but which happen to be out of condition or in a state of fermentation, such as puddings, custards, pies, sauces, ice-creams, and canned meats. The symptoms usually come on suddenly, and from one to three hours after eating the offending substance. Vomiting is generally simultaneous with the purging, but may cease before the latter. The diarrhœa may continue after the digestive tube is apparently completely evacuated of all fæcal matter and food, and may even lead to a fatal termination. In the severe cases the later passages are mucous and watery, with possibly an admixture of blood, and pains, cramps, great prostration, and profuse sweating occur in varying degrees. In mild cases all symptoms cease after the evacuation of the stomach and bowels.

Diarrhœa is a prominent symptom of many cases of *typhoid fever*. The stools are generally yellowish, ochre-colored, and semi-fluid in character, and may contain blood. Frequently not more than one such passage, rarely five or six, occur daily, while sometimes a loose stool may be passed only once in two or three days. In cases in which only a few glands of the intestine are inflamed or ulcerated, and these confined to the ileum, the colon is tolerant of the products of the ulcers as well as of fæcal matter, and constipation may exist; but where the glandular involvement extends to the large intestine diarrhœa is almost certain to occur.

Diarrhœa is a frequent symptom in pulmonary consumption. It has most of the characteristics of the diarrhœa of indigestion, which it mainly is. Food is passed undigested, evidences of fermentation exist, the stools are thin and watery. Several passages may occur in rapid succession, especially after eating heartily. In an advanced stage of phthisis a dejection often follows so closely upon even a small, bland meal as to suggest the complete intolerance of the whole alimentary canal to the presence of food, as well as its incapacity for digestion and absorption; moreover, the food is much of it passed with slight evidence of having undergone any digestive change. In a certain proportion of such cases there is secondary tuberculous ulceration of the intestines, but this alone does not necessarily nor frequently produce diarrhœa, unless the colon is involved. Numerous tuberculous ulcerations of considerable size may exist in the small intestine without announcing their presence by any symptom during life.

A form of diarrhœa results from chronic *ulcer of the rectum*. It consists in frequent discharges of small quantities of a slimy mixture of mucus, pus, and blood, with little fæcal matter, and this little in the form of scybalous masses which are voided at varying intervals. Tenesmus may be present, but frequently is not, and often there is little or no pain, unless the ulceration reaches the anus, when pain is always present at the time of defecation, and for a few moments afterward.

Diarrhœa of *constipation* is a designation justified by clinical observation. Fæcal matter accumulates in the colon, distends it, becomes hard and dry, and finally lights up, at the lowest point, an irritation which announces itself by frequent small discharges of mucus, serum, and fragments of the fæcal mass, possibly with pain and tenesmus. It is not necessary in these cases to suppose a complete blocking up of the large intestine; fæces may accumulate and remain for months, and repeatedly allow small soft feculent passages to escape by the side of the indurated mass or through a hole in its centre.

After the discharge of a large mass of long-retained fæces, the colon is not infrequently left in a condition of catarrh which may prolong a diarrhœa for several days. In most of these cases, as in many cases of diarrhœa in general, there is failure of free drainage of the large intestine in some part, mostly below the central point of the transverse colon.

In general *peritonitis*, contrary to a nearly invariable rule, diarrhœa is occasionally present at some stage of the disease. Vomiting nearly always attends it, and not infrequently hiccough. In metroperitonitis, on the other hand, diarrhœa is frequent, owing presumably to the involvement of the lower bowel in the inflammation, as a result of which there is developed a catarrh of the mucous membrane of this part. Diarrhœa is an occasional event in several diseases of the kidneys (*e.g.*, in Bright's disease). In desquamative nephritis the intestinal mucous membrane appears to become œdematous with the rest of the body, and a free effusion of serum brings on occasional paroxysms of diarrhœa. In *uræmia* from any renal disease, urea may be discharged into the intestine and cause diarrhœa, perhaps principally by its conversion into carbonate of ammonium after its entrance into the canal. Diarrhœa is a rare event late in *contracting disease* of the kidneys, due presumably to uræmia. In *amyloid degeneration* it is more common, is liable to be irregular, and may be protracted, is occasionally hemorrhagic, and always rebellious to all treatment. *Tuberculosis* and *cancer* of the kidneys may be attended by diarrhœa probably from uræmia, and possibly in the case of the former by the concurrent existence of tuberculosis of the colon.

In *intussusception* diarrhœa is usually present in some degree at some stage of the case. The stools are few in number and composed of mucus and blood to a considerable extent, and there is frequently tenesmus, especially if the invagination is at the ileocæcal region or below it. In *constriction of the intestine* constipation is the rule, but diarrhœa may alternate with it or be a nearly constant symptom. Two theories of this phenomenon are advanced, one referring it to the increased peristalsis provoked by the constriction, the other to ulceration which sometimes supervenes below the point of stricture.

Diarrhœa occurs rarely in *cancer of the pancreas*, and nearly invariably in *cirrhosis* of this organ. In the former, secondary deposits are sometimes found in the intestinal walls, which may account for the symptoms. In leukæmic enlargement of the *spleen* diarrhœa sometimes occurs, the motions being bloody and most of them purulent; they may, however, be profuse and watery.

Recurring diarrhœa may attend degeneration of the *suprarenal capsules*, brought on probably to some degree by the debility which characterizes the disease, but also by the disturbance of the semilunar ganglia and the sympathetic which must ensue from the marked lesion which occurs in them in many cases of Addison's disease.

Diarrhœa makes a part of the pathological picture of the *teething* of infants (see *Diarrhœa, Infantile*).

In *cirrhosis* and other diseases of the *liver* constipation is the rule, yet it may be varied by an occasional sharp attack of diarrhœa, which for the time depletes the distended vessels of the portal system.

Intestinal catarrh has been charged with producing diarrhœa with some constancy, as though this symptom might result wherever the catarrhal process was located. It cannot be doubted that catarrh attacks all the different portions of the alimentary mucous membrane. Of course, catarrh of any part in some measure interferes with digestion, and in this way may indirectly be a cause of diarrhœa. In chronic catarrh of the small intestine constipation is almost constant; in the catarrh of the colon, acute or chronic, diarrhœa is rarely absent. The tendency to chronicity is particularly noticeable in the diarrhœa of chronic dysentery and of general anæmia from any cause, but especially from dyspepsia, phthisis, and other diseases capable of inducing general cachexia.

ETIOLOGY.—Many of the general causes of diarrhœa have been referred to already Often, indeed generally, several influences, direct and remote, act together as causes. The remote, the predisposing causes are any and all influences that lessen the vital tone of the intestinal canal and depress the powers of digestion, and that increase the irritability of the nervous apparatus of the intestines. To this class belong the depressing influence of hot weather, especially on infants and children; of cold, overwork, bad ventilation, starvation, worry and grief of mind, and all the long list of depressing emotions.

The immediate pathological conditions that produce diarrhœa may be named under a few general heads; the circumstances under which they occur are numerous. The following is believed to be a logical classification of the causative conditions:

1. *Solution of Continuity and other Structural Damage to the Intestinal Walls.*—Ulceration, and the catarrh in adjacent tissue which it entails, occur in different parts of the intestinal tract and under different circumstances: in the rectum and colon, for example, in chronic dysentery; in any part of the intestine, as in tuberculosis, in amyloid and perhaps other degenerations of the intestinal walls, in typhoid fever and in intussusception and constriction of the intestines. Intestinal ulcers also develop as a result of extensive scalds and burns of the surface of the body.

2. *Inflammation,* of the colon and rectum mainly: proctitis, colitis (dysentery); the inflammation associated with intussusception, with cholera, with peritonitis, and with cancer and tuberculosis of the intestine.

3. *Congestion,* otherwise catarrh of the mucous membrane of the intestine, mainly below the ileum, without actual inflammation: the catarrh of cholera, cholera morbus, cold-catching, chilling of the surface of the body in whole or in part, invagination, obstruction to the portal circulation in cirrhosis of the liver and cardiac disease, peritonitis, leukæmia, zymotic poisons, the eruptive fevers, a long list of general diseases, and of irritations of foreign bodies, especially drastic drugs.

4. *Increased irritability* of the intestine with hyperperistalsis. This arises from depressing emotions: debility, systemic or nervous; bad hygiene in its multiple shapes; the reflex effect of teething and manifold other influences capable of reflex action in this direction, especially diseases in other organs; constriction of the intestine, and personal idiosyncrasy.

5. *Irritating Intestinal Contents.*—The results of (*a*) gastric dyspepsia, over-eating, improper or improperly masticated foods. The result of (*b*) intestinal indigestion, from abnormality of the liver or pancreas, from loss of secreting substance by previous or existing ulceration, from atony, catarrh, or inflammation. (*c*) Cathartics and other irritating substances, either swallowed or developed in the intestines: as, for example, cathartic medicines; impure or strongly saline drinking-water; various poisons, including foods undergoing fermentation; excessive transudation of serum into the canal, as in choleraic disorders and in the colliquative diarrhœa of depressing diseases; pus, blood, or mucus in quantity; the rinds, hulls, and seeds of fruits, grains, and vegetables; retained fæces, the entozoa, the entophyta, urea, as in renal affections, and finally the special micro-organisms of disease. Microbes characteristic of diarrhœa, as amœba coli and bacillus dysenteriæ, have been found to be present in the intestine in severe cases of this disorder, and to disappear with its subsidence; but whether they are the cause or consequence, is not established. Excess of bile thrown into the duodenum after the removal of an obstruction may cause diarrhœa, but it is not known, as alleged, that so-called vitiated bile is capable of doing it. Ptomaïns developing in the digestive tube from decomposition of ill-conditioned foods may cause sudden violent purging, as in cases due to old ice-cream. Ptomaïns probably also sometimes develop from decomposition of retained substance in extreme constipation, and cause occasional explosions of diarrhœa.

DIAGNOSIS.—The simple diagnosis of diarrhœa is easy enough; the important and often difficult thing is to learn the cause and nature of the disorder. The dejections should be inspected for foreign bodies, undigested food, products of fermentation, pus, blood, mucus, etc. (See *Fæces.*) As diarrhœa is often due to indigestion, it is important, when this is present, to determine what part of the alimentary canal or what other organ, if any, is at fault. A consideration of the physiological functions of the different parts and of the symptoms of the case will usually lead to the discovery of the region or organ involved. It is equally important to learn what articles of food fail of digestion, and in what quantities and under what circumstances as to times of eating, methods of preparation, etc., they have been ingested. By careful observation and by exclusion this may be done, and so the first step in successful treatment may be attained. If the attack is not due to indigestion, irritation, or catarrh, inflammation or ulceration of some part of the alimentary canal should be looked for. A considerable degree of inflammation of the mucous membrane may exist without fever; the absence of this, therefore, does not exclude inflammatory action. In a majority of cases caused by the lesions referred to, the trouble is in the rectum or colon; for inflammation, catarrh, indigestion to a moderate degree rarely cause diarrhœa, provided the bowel below the ileo-cæcal valve is normal. The seat of the irritation may often be known by the location and characteristics of the pain. Pain in the region of the umbilicus, just before and disappearing immediately after a passage and without tenesmus or pain in the rectum, locates the trouble, with fair accuracy, in the transverse colon. If tenesmus exists, with pain in the region of the rectum, that part is involved. Tenesmus is a reflex effect of irritation of the mucous membrane of the rectum—nature's effort to be relieved,—a symptom having a very narrow signification. Pain, on the other hand, while it may be purely neuralgic, may indicate inflammation in any of the tissues of the rectum or outside of it in the pelvis. The colicky pain often experienced in diarrhœa is usually in the large intestine, as in dysentery. Inflammation—even extensive ulceration—of the small intestine is not ordinarily attended with diarrhœa. nor with colicky pains. Pain in the anus in the act of defecation and following it points strongly to hemorrhoids, fissure, or abscess in the adjacent tissues.

The significance of blood in the stools differs with its appearance and with other symptoms. Bright, fresh blood indicates a lesion of some part near the extremity of the bowel—the anus (fissure, hemorrhoids), rectum (ulcer, hemorrhoids), or colon (ulceration, or deep congestion, or inflammation). When the blood simply streaks the fæces, it comes generally from small vessels inside the sphincter. Fresh clots seldom appear if the blood comes from a point high up in the intestine. In typhoid fever the blood of a hemorrhage is usually fluid and mixed with the fæcal matter. Very dark or blackish blood usually comes from the upper portions of the intestine or stomach; a copious bleeding from an ulcer of the latter, or from the duodenum, as in cutaneous burns, may easily produce such an appearance. Dysenteric stools of true dysentery, of intussusception, and of ulcer and hemorrhoidal troubles, often bear a close resemblance to each other; the distinction between them must be made by other symptoms. Intussusception usually announces itself by the suddenness with which the symptoms develop, of which colicky pains and vomiting are seldom omitted, and after a time the vomiting is apt to be stercoraceous. In dysentery the vomiting is not so marked a feature,—indeed it is often absent,—and the colic is less violent, but colicky pains are rarely absent. Ulcerations and hemorrhoidal projections into the rectum do not induce either colic or vomiting, nor, at first, much disturbance of the health. The sudden discharge of pus in large quantity indicates the bursting of an abscess, and is rarely unaccompanied by symptoms and signs indicating the character and location of the latter. Small quantities of pus mixed with the fæces point to ulceration in the lower part of the canal. Large watery stools are usually the product of both the large and small intestines. Mucus in the stools always means catarrh somewhere in the bowel; the purer and clearer the mucus the nearer is the area of the catarrhal process to the anus. Scybala besmeared with mucus or muco-pus point to catarrh, possibly to ulceration in the rectum, and certainly to the retention of the fæcal matter for some time in a given part of the canal.

Dark, blackish, or chocolate-colored stools suggest the presence of the coloring matter of blood,—blood arising from a point high up in the canal and changed by the secretions of the stomach and bowels,—or the effect of some medicament, as bismuth, hæmatoxylon, mercury, or iron.

Green stools are not always nor usually produced by excess of bile, as is often supposed, but by biliverdin, an oxidation product of bilirubin, and developed in the intestinal canal. When diarrhœa arises from disease of the kidneys, liver, spleen, pancreas, suprarenal capsules, or from some general disease capable of inducing it, the symptoms of the causative disease usually predominate and identify it. But diarrhœa in tuberculosis is not evidence of a tuberculous process in the small intestines, nor proof of its existence in the colon. In chronic diarrhœa the urine should always be examined for evidence of disease of the kidneys, the urine for twenty-four hours being secured, if possible, and an accurate determination made of the urea and total solids. The diagnosis of lardaceous change in the intestines cannot be made from the intestinal symptoms alone. Chronic dysentery and chronic catarrh of the colon of a severe type are indistinguishable by the symptoms, as in many cases they are pathologically identical. Dysentery and proctitis are occasionally mistaken for each other. But the distinction is not difficult usually, since in dysentery there are some constitutional symptoms—colicky pains, borborygmi, fever,—while in proctitis the symptoms are confined more to the rectum.

In typhoid fever of sufficient severity to cause diarrhœa there are always continued fever, cephalalgia, pain in the back and extremities, or other typhoid symptoms, as well as the typhoid Widal reaction. But an acute catarrh of the upper part of the colon may at first be attended with fever and other constitutional symptoms that, by their resemblance to typhoid fever, justify hesitation in adopting a diagnosis.

TREATMENT.—The majority of acute diarrhœas are due to indigestion of some sort and are of short duration. Their treatment is simple; they are often corrective and remedial in themselves, expelling offending materials and subsiding promptly without any treatment. The restoration is more prompt if, after its contents have been evacuated, the intestine can have a brief period of rest. Hence, a low diet and fasting are among the best of remedial measures. Absolute fasting is not necessary, but till convalescence is established the diet should be low Important as this is for slight attacks, it is much more urgent in prolonged and severe ones, especially in weakly people and in children. The patient may be nourished by gastric digestion as far as possible, and thus the intestine may be given rest. Stale bread and light crackers are the best farinaceous foods; corn starch, rice, tapioca, and arrow root are less eligible. Milk is the best fluid food. If fresh, it may be taken raw; otherwise it is better pasteurized (heated to from 160° to 170° F.; it should never be boiled, as thereby its digestibility is reduced.) Beef-tea is admissible only if largely composed of fine particles of muscular fibre; beef-tea that is transparent throughout is not good. Beef juice is highly nutritious and easily assimilated; scraped raw beef is one of the best possible foods for diarrhœa in any age or condition, and may be eaten almost *ad libitum*. It is rarely objected to by the patient, and if it is it can be easily made palatable by the addition of sugar, salt, pepper, and spices. Eggs, raw or slightly cooked, are always allowable; very slight cooking adds to their digestibility. Uncooked white of egg may be mixed with water and taken as a drink, or in any other way that the patient may prefer. Six to ten eggs may thus be used by an adult each day. Oysters, slightly cooked, or preferably raw, are digested easily and rapidly by the stomach, as are also tripe and pigs' feet. Liquid foods, especially milk, may with great advantage be peptonized. Peptonizing of foods is an excellent procedure in any diarrhœa in child or adult. The time and frequency of eating should be regulated carefully, especially in severe and protracted cases. By trial of small portions of food the dose should be found which can be taken without disturbing the intestine, and this should not be exceeded. Next, by trial, the greatest frequency with which this small meal can be repeated without harm is to be determined and adhered to rigidly, whether the daily number be three or ten.

In the simple cases due to indigestion, beyond the regulation of the diet, rest and warmth of the body, very little treatment is called for. A slight stomachic stimulant or an opiate, to check pain and nervous perturbation, may be needed at first, or later if the attack is prolonged. If pain is sharp and purging severe, opiates should be given promptly, and by the hypodermic method, if vomiting renders absorption by the stomach uncertain. One of the best combinations of opium for internal administration is the camphorated tincture; the deodorized tincture is an ideal fluid opiate; but the best preparation of all is morphine. Chloroform, ether, tincture of capsicum, aromatic spirit of ammonia, and other aromatics are frequently used alone, or added to the opiate with happy effect; but the opiate alone is nearly or quite as useful, and has the advantage of simplicity. The subnitrate and salicylate of bismuth are good adjuvants to the opiate.

For the diarrhœa of indigestion and biliousness, it is a good plan of treatment to give repeated small doses, or a single large dose, of some laxative, like castor oil, rhubarb, or the salines, with, or followed by, a few drops of tincture of opium. Much of the good effect of this plan of treatment is probably due to the free expulsion of offending material, inlcuding micro-organisms and ptomaïns. For the diarrhœa of indigestion—especially the more chronic cases—nothing will take the place of measures to improve the digestion. Alcoholic liquors, tobacco, and coffee, as well as stimulating condiments, if they have been used, should be abstained from as far as possible.

Tonics are indicated for the general health and for digestion, and the patient should rest from labor and have the best of hygienic influences. Of the general tonics the most useful are quinine, iron, strychnine, arsenic, and mineral acids. One tonic that deserves to be more employed for diarrhœa than heretofore is the solution of nitrate of iron. Sulphate and phosphate of sodium, ipecacuanha and euonymin exercise a tonic influence upon the digestive function of the intestine, liver, and possibly the pancreas. Diarrhœa produced by fermenting and poisonous food tends to be severe, and treatment should be prompt. It is usually best to give morphine hypodermically, as it is unsafe to trust to slow absorption by the stomach. A dose of gr. $\frac{1}{8}$, repeated in thirty minutes if necessary, will usually stop the diarrhœa as well as the vomiting. Rest and warmth to the extremities must be enjoined.

Acute diarrhœa in children is usually susceptible of prompt improvement by an early regulation and lowering of the diet. But first the alimentary canal must be thoroughly evacuated of all undigested food and irritants. A slight diarrhœa, even for a day or two, is no proof of such evacuation. A laxative like oil or calomel should be given whenever it is suspected to be necessary. A cathartic has not infrequently removed undigested food taken several days before, with prompt relief of the diarrhœa. The diet should at once be reduced to one-third the usual allowance, and it should be taken in the form of numerous meals; this course should be pursued, if possible, till some improvement takes place in the symptoms, even if it requires a day or two. Then, as the conditions improve, the quantity of food may be gradually increased. Food in the slightest excess of the powers of digestion is generally harmful and aggravates the diarrhœa. If regulation of the regimen is not followed by prompt improvement, or if a catarrh of the bowels supervenes, minute doses of hydrargyrum cum cretâ, or of calomel, often repeated, may be efficacious. A tenth of a grain of calomel or an equivalent dose of the other preparation may be given every two hours, till some improvement shows itself in the stools. Next to this in value—perhaps superior to it, for children as well as for adults—is the subnitrate of bismuth, which, if pure, may be taken in large doses. A child of two years may take from gr. v. to gr. x. every two to four hours, although smaller doses are valuable. This medication should not be continued for a period of many days, for fear of the effects of retained insoluble bismuth salts.

If the diarrhœa persists, in spite of the bismuth, and if the discharges are of a watery character, the milder astringents, in small doses, may be tried, although they are not very useful medicines. The best of them are, perhaps, kino, catechu, and logwood.

To check a bloody flux, or a sudden attack of diarrhœa as it occurs in epidemics, the best course is the opiate treatment, with fasting. A hypodermic injection of morphine is probably the most potent remedy extant for checking an internal bleeding of any kind. In cases of hemorrhage from the lower bowel astringents are of little consequence, and ergot is harmful.

Chronic diarrhœa in adults, when apparently due to atony, debility, tuberculosis, or other constitutional disorders, and not to demonstrable ulceration, may be treated with mild astringents; these will do some good, but little in comparison with regimen. Probably a diet of scraped raw beef, of egg, or of peptonized milk, in minute portions, promises more than all the astringents combined. But in some of these cases, even after the most careful regulation of the diet, and after a certain amount of improvement in the digestion has taken place, the diarrhœa continues to a slight extent. Such patients sometimes feel better, are more comfortable, and improve faster if they are continually taking mild astringents or astringent tonics in small doses.

When fermentation occurs in the intestinal contents, anti-fermentatives are indicated. Perhaps the most valuable of these are the salicylates, the sulphites, the naphthols, the carbolates, and salol. Salicylate and subgallate of bismuth are rational remedies for fermentation in connection with diarrhœa, and they may be taken in doses of from gr. v. to gr. xx. every two to four hours.

In all cases of diarrhœa that are severe or persistent the body should be kept constantly and consciously warm, thus lessening internal congestion. The body should be in a horizontal posture as many hours as possible every day, since this favors recovery from intestinal diseases.

The treatment of many of the more chronic forms of diarrhœa by enteroclysis or by injections of sterilized water containing various medicaments is very proper.

Norman Bridge.

DIARRHŒA, INFANTILE.—Definition.—Diarrhœa is a term used to designate all conditions arising from an increased motor and secretory activity of the intestinal tract. It is thus but a symptom, and may be met with in every degree of severity, from a mere looseness of the bowels to a profuse watery drain, exhausting the patient and resulting in death within a few hours. Infants are peculiarly susceptible to diarrhœal disorders, which tend in them to run a more severe course, and to terminate more often fatally, than is the case in older children or in adults.

Classification.—It is very difficult and probably, in our present state of knowledge, impossible to give a satisfactory and scientific classification of the diarrhœas of infants. All do not fall into any grouping according to pathological anatomy, for some are functional and leave no lesion. Booker has made an attempt at a scientific classification based on the bacteriology of the discharges. But our present knowledge of bacteriology, and the fact that all diarrhœas are not of bacterial origin, render this incomplete. One is forced, then, to make use of an enumeration rather than a classification. For convenience of study we would offer the following:

Diarrhœa.

- I. Acute.
  - 1. Non-infectious.
    - (*a*) Mechanical.
    - (*b*) Irritative (drugs, etc.).
    - (*c*) Nervous.
    - (*d*) Eliminative.
  - 2. Infectious.
    - (*a*) Acute mycotic.
    - (*b*) Cholera infantum.
    - (*c*) Ileo-colitis.
- II. Chronic.

I. Acute Diarrhœa.

1. Non-Infectious.—(*a*) The *mechanical diarrhœas* result from the ingestion of foreign bodies or of foodstuffs which, from their character or their unsuitability to the feeble digestion of the infant, act as mere foreign bodies. By directing blood and nervous energy to the intestine in the absence of absorption, this material then produces diarrhœa until nature or a purgative empties the intestines. The commonest materials leading to this diarrhœa are partly cooked cereals, the coarser vegetables, unripe fruit, nuts, etc. The symptoms are those of acute indigestion. Following vomiting perhaps, come colic, some distention, and diarrhœa. An uncomplicated case shows no pathological changes.

(*b*) The above merges imperceptibly into the *irritative diarrhœa* where such irritating substances as the organic acids of fruit, or their seeds, or various drugs are added to the offending material. The various drugs, which in adults produce diarrhœa, do not frequently come into question, but too drastic purgatives often leave a hyperæsthesia which produces abnormal peristalsis and secretion until soothed by suitable treatment. Congestion and catarrh are rapidly produced, and steadily proceed to ulceration in the lower bowels if treatment is not prompt. The symptoms are those of the previous group intensified.

(*c*) *Nervous diarrhœas* form a large and important group of cases. The process of dentition is probably an irritation which leads to diarrhœa by reflex action. There certainly are diarrhœas which appear with the onset of dentition, persist in spite of ordinary treatment, and cease on the eruption of the teeth. These cases drag on longer than the above, the symptoms vary in intensity irrespective of careful regular diet, and the child remains irritable, restless, and sleepless.

Fright and surprise may cause slight temporary diarrhœa. Fatigue arrests digestion, and so causes diarrhœa. Cold, especially a sudden drop in the temperature, is a fruitful source of diarrhœa in infants as in adults, acting probably through nervous and vaso-motor mechanism. In the same way and by general depression, extreme heat is the all-important cause of summer diarrhœas.

(*d*) *Eliminative diarrhœa* occurs in cases having an inefficiency of excretory organs other than the intestines, or toxæmias of any kind. Renal inefficiency provides the commonest example so far as we know, and Holt suggests that the diarrhœa met in acute infectious fevers is of this nature. In this entire group of non-infectious diarrhœas, if the condition is promptly cured by nature or by treatment, and no complications are added, there is nothing typical in the stools. The bacteria found are those of the normal intestine. If the irritation is of moderate degree and of short duration, one may find only increased frequency of fairly well-digested stools, *i.e.*, the only result is increased peristalsis. Greater or longer irritation will produce more fluid in the stools—increased secretion. If the disturbance lasts many hours the liver's functions are affected, and one finds dark brown, greenish, or grass-green stools, on the one hand, or motions suggesting clay or chalk on the other, as the biliary functions are variously perverted or inhibited. Foods in various stages of digestion are recognized.

2. Infectious Diarrhœas.—(*a*) *Acute Mycotic* (Acute Gastro-enteric Infection).—This is the great summer trou-

ble of infants, occurring as regularly as does the heat of summer. In this form of disease bacteria or their toxins make their way into the general circulation. Thus a grave systemic intoxication is added, and the most alarming symptoms now depend on the poisons which are circulating about the vital centres. These poisons are not necessarily introduced as such from without, but while the heat arrests all digestion, putrefaction produces toxic material which is duly absorbed. Thus, any cause of arrest of digestion may become the cause of acute mycotic diarrhœa. The exciting cause is frequently also the direct introduction into the alimentary tract of infection. Thus both saprophytic bacteria and the well-known infecting forms (proteus, pneumococci, streptococci, etc.) may be the immediate cause. Feeding infants upon cow's milk which has been brought from a distance, and kept perhaps, in hot weather and dusty cities, provides the ideal conditions for infection. (This suggests the question of contagion as well as infection; and disinfection, at least as much as we advise in the case of typhoid fever, is recommended.) Predisposing causes are age (from birth to two years), general feebleness from whatever cause, bad hygienic surroundings (including institutional life), and any interference with the barrier formed by the normal mucous membrane of the alimentary tract. Thus any influence which damages the mucous membrane is the all-important predisposing cause. As continued congestion lowers the nutrition of the epithelium, probably this alone prevents the perfect protection against absorption of toxic material. Greater degrees of damage are catarrh and superficial ulceration. As these are all produced by the previously mentioned non-infectious troubles when the latter are not promptly cured, we find that an uncured attack of non-infectious diarrhœa is a very frequent predisposing cause of acute mycotic diarrhœa.

Symptoms. The symptoms may, in mild cases, be those of the previous groups slowly and gradually exaggerated and prolonged. Mere diarrhœa may for a day or two be the only symptom, but at a time when, in the non-infectious cases, recovery takes place, the child in this disease becomes more peevish and fever may appear. Here time is often lost by parents, and the physician is called when too late to prevent systemic infection. The stools become more frequent and fluid, and evidences of systemic disease become prominent. These are fever, restlessness, rapid pulse, beginning pallor, and loss of weight. Other cases may be recognized as mycotic from the onset, which is sudden and severe. Violent vomiting, high fever, and severe nervous symptoms, such as stupor, delirium, or convulsions may usher in the attack. Increasing diarrhœa soon appears and rapidly leads to the usual signs of exhaustion of fluids from the body, *e.g.*, thirst, dry tongue and skin, sunken eyes and fontanels. The child's age, nutrition, and constitution now largely determine the course of the symptoms. Puny infants succumb in several days, perhaps in spite of treatment. Even mild attacks often linger a week or more with symptoms of varying severity, while severe cases linger longer. In all a marked indiscretion of diet precipitates a serious and prolonged relapse or throws the case into the group of ileo-colitis. As improvement sets in, fever and the nervous symptoms diminish and disappear more rapidly than the local manifestations.

Pathology. Stools rapidly become fluid and bulky, containing undigested food particles. Various tints from yellow and brown to greens appear, and the motions are early characterized by an unusual offensiveness and much flatus. Occasionally in a sudden virulent case the only discharge after the first few evacuations is a clear yellow fluid. At least at the onset, the stools are of acid reaction. Microscopically one finds food particles, epithelial cells, scanty leucocytes, and hosts of bacteria. The information from the stools is still unsatisfactory, and the list of bacteria is as yet incomplete.

The stomach may show patchy congestion, but it is in the lower part of the small bowel and in the colon that lesions are found. The upper parts of the small bowel are generally empty and the mucous membrane is normal. The ileum generally contains such material as one finds in the stools in life, or its mucous membrane shows an intense congestion, while the lymphatic structures (Peyer's and solitary) are congested and swollen. Congestion has gone on to catarrh in many parts, particularly in the colon where mucus frequently adheres to the lining membrane. The stomach and various parts of the colon are often distended with gas.

(*b*) *Cholera Infantum.*—This term is still used for those severe virulent infections accompanied by rapid development of choleriform diarrhœa and grave depression of the heart, the nerve centres, and the nervous system generally. The terminal symptoms are due to the extreme abstraction of fluid. In some cases grave systemic symptoms, such as high fever and general depression, are present before any local symptoms appear. Vomiting and diarrhœa may come on simultaneously, and very frequent, large, watery discharges occur with alarming rapidity leading quickly to grave prostration and signs of extreme abstraction of fluid. The stools often resemble rice water and may be odorless, but are occasionally very offensive. Thus the onset, the symptoms, the course, and the pathology show this condition to be an example of the preceding group with greatly exaggerated virulence. Cases which do not end fatally in about twenty-four hours show, when treated, considerable control of the local symptoms, while the nervous manifestations linger more obstinately. Those dying early show extreme collapse, high fever, clammy skin, thready pulse, etc., as in cholera. Patients who slowly improve may lapse into ileo-colitis. Holt's experience is against the idea that renal or cerebral affection accounts for the nervous symptoms or the fatal termination. A very sudden relapse after marked signs of improvement, rapidly develops the most dangerous symptoms.

Pathology. The lesions still are confined to congestion and catarrh, especially in the above-mentioned localities, but the reaction appears more angry, and microscopically one finds much more numerous epithelial cells in the discharges. Thus we are here just on the verge of gross loss of substance, in fact, the patient generally dies before the poison has had time to erode the mucous membrane.

(*c*) *Acute Ileo-Colitis* (Dysentery).—In this group we place those cases which show a pathological process more advanced than mere congestion, with exaggerated function (mucus production) and degeneration (shedding of cells) of the epithelial lining of the intestine. We now find all grades, from a slight superficial abrasion to large deep ulcers with undermined edges, involving perhaps all coats of the bowel (dysentery).

Etiology. What has been said above on etiology applies here, as we are generally dealing with an advanced stage of one and the same process. Typical cases are seen up to five years of age or more.

Pathology. Booker found streptococci almost constantly present in the deeper ulcerations, but they may be only secondary. Cohen and others have found, in a small number of cases, the amœba coli in the stools of typical examples. But such is not the cause of the host of cases occurring with regularity in every summer and following steadily on the milder forms when improvement does not occur.

As in the milder forms, the lesions are found in the lower ileum and the colon.

1. The mildest form of lesion is an inflammatory infiltration into the catarrhal area with swelling of the mucous membranes, and particularly the solitary follicles. The infiltration may extend into the submucosa, and produce œdema which gives the surface a velvety appearance. Microscopically one finds great shedding of epithelial cells, the goblet cells distended with mucus, the glandular orifices narrowed or obliterated by pressure, and a large amount of mucous débris, great congestion, and occasionally hemorrhagic areas.

2. A more advanced stage is a catarrhal ulceration, which is extensive perhaps, but not deep, being limited

by the mucosa and showing generally a lymph follicle within it. If the ulcer is extensive the submucosa is infiltrated, but one does not see prominent edges to the ulcer.

3. Follicular ulceration is the commonest lesion. A small ulcer is seen on a solitary follicle in places, while in others the entire follicle breaks down leaving a round ulcer with overhanging edges, and often exposing the muscular coat. Infiltration continues extending beyond the follicle, and later this infiltrated area breaks down chiefly in the submucosa, thus enlarging the ulcer by undermining the mucosa. In severe prolonged cases the circular layer of the muscularis ulcerates. Perforation rarely or never occurs. If recovery takes place cicatrization is delayed for several months.

4. Membranous ileo-colitis, which is fortunately rare, is the most virulent form. Slight pseudo-membrane is seen in the lower ileum and throughout the colon, of a gray or green color with deficiencies here and there, through which the mucous membrane may be seen intensely injected, dull, and rough. Microscopically, fibrin containing small round cells, red blood cells, and bacteria, is seen to form the membrane, and may be seen invading the mucosa and submucosa. Inflammatory infiltration, œdema, and the pseudo-membrane greatly thicken the bowel.

Symptoms. In the cases due to inflammatory infiltration the onset is sudden, though the first twenty-four hours may be taken up by symptoms of mere indigestion, pain, vomiting, and repeated stools. Later, the old classical symptoms of dysentery appear, frequent small stools consisting mostly of blood-streaked mucus, passed with great pain, and tenesmus threatening prolapse of the rectum. The motions generally become dark brown in color, and tenderness is elicited over the colon. High fever slowly and gradually becomes moderate, while prostration slowly increases. Symptoms always remain severe as long as a week, the first improvement in the stools being the disappearance of blood; then the frequency and tenesmus diminish, while the mucus lingers for weeks. In catarrhal ulceration all is more severe, the noticeable additions being steady high fever, very frequent stools now containing much blood, greater prostration, and nervous symptoms. If death does not occur the case remains obstinately severe for weeks when complications are likely. Improvement and convalescence are very tedious, and recovery is occasionally incomplete.

Follicular ulceration may be ushered in with suddenness or, as is more frequently the case, symptoms are subacute and gradual, as one would expect from lesions of a chronic inflammation. In the former case one finds high fever and in the latter a rather steady moderate fever (about 100°). The lesions are so chronic and sluggish that blood is generally absent from the stools, whose typical feature is abundant mucus with numerous epithelial cells and small round cells. Very steady, though slow, failure in nutrition, color, and weight continue, with loss of appetite and grave trophic disturbances (bedsores); ulcers in the mouth, pain, and absence of tenesmus confirm the chronicity of the local inflammation.

The most virulent form, the membranous inflammation, produces a sudden, severe onset of symptoms with vomiting, high fever, and fluid stools. Very early the temperature may be between 102° and 105°, and it is typically steady and high. Systemic symptoms, prostration, delirium, etc., appear at the onset and are grave. Pain and tenesmus are severe, but wellnigh constant, not intermittent, as in the previously described cases. Prolapse is frequent and reveals sometimes an angry mucous membrane, supporting pseudo-membrane. Stools show more blood than less virulent cases, and portions of pseudo-membrane are to be looked for. Small pieces, gray and opaque, are easily recognized.

II. Chronic Diarrhœa.

Chronic diarrhœa completes our classification, but is not a specific affection, inasmuch as it may be the result of any lingering, obstinate acute case of the previous groups. Thus it may be caused by an acute diarrhœa lapsing into chronicity or, as it often does in young foundlings, it may result from months of indigestion with the irritation of partly digested food particles. In the latter cases atrophic conditions of secretory apparatus and of the mucous membrane generally, plays an important part. In such conditions fermentation is ever present and toxic material is constantly being absorbed, and a mild chronic intoxication occurs and may lead toward marasmus, while intercurrent disease is always probable. These are the cases one meets with in puny foundlings which show slight gains alternating with slight losses or a long, slow decline without any acute disease.

Diagnosis.—Gastro-enteric symptoms frequently usher in almost any acute disease in infants in summer. This is particularly the case in pneumonia and tonsillitis; hence in every case a careful examination of the chest and throat should be made.

The non-infectious diarrhœas are characterized by their mildness and by the rapidity with which they subside. The infectious forms are generally characterized by higher temperature and more severe disturbances of the nervous system than is the rule in the former class of cases. The infectious forms are generally marked by highly offensive fluid evacuations, and they occur epidemically in summer.

Ileo-colitis can be recognized, only after the lapse of several days, by the persistence of temperature and the appearance of blood and large quantities of mucus in the motions. The pain and tenesmus are more marked than in any other form.

Cholera infantum can usually be recognized without difficulty by the severity of the general symptoms and by the fluid and offensive motions.

The onset of typhoid fever may be accompanied by diarrhœa, but this disease is rare in infancy, and is not likely to occur unless the disease is epidemic. The Widal test may be resorted to, but cannot be relied upon for diagnosis; it is not infrequently absent until later on in the disease in the case of infants.

Intussusception, which may be confounded with ileo-colitis, is to be distinguished by the absence of elevated temperature for the first few days.

Prognosis.—In the non infectious forms the prognosis is invariably favorable, except in so far as they open the way for general gastro-enteric infection. In the infectious forms the prognosis depends on the general condition of the child, the virulence of the infection, and the efficacy of treatment, hygienic and medicinal.

In the case of young infants suffering from chronic dyspeptic troubles, the occurrence of an infectious diarrhœa is an extremely serious matter. Even an apparently mild attack may prove fatal, hence a guarded prognosis should always be given. The favorable symptoms are a decrease in the temperature and in the frequency of the motions *when associated with an improvement in the general appearance and in the character of the pulse.*

The prognosis is rendered more serious by the presence of a higher temperature, more watery movements, suppression of urine, sighing and feeble respiration, and a weak and intermittent pulse.

Complications.—No complications are to be met with in the non-infectious forms of diarrhœa.

Probably the most common complication of the infectious forms is broncho-pneumonia. Its onset is generally very insidious; it is generally accompanied by an increase in the respirations and a distinct rise in the temperature. The physical signs are obscure, but when noted are generally found at the base of the lungs. Symptoms of cerebral congestion are occasionally encountered.

Parenchymatous nephritis is a rare complication, but it has been noted in several instances. Koplik (*Medical Record,* April 1st, 1899) considers that it is more common than ordinarily supposed. When the affection is of a mild type, nothing may be found but a slight albuminuria; when severe, it is manifested by restlessness alternating with periods of a sort of stupor. It may be accompanied by œdema of the skin and subcutaneous tissues, and is generally associated with more or less complete suppression of urine. The complication may appear early or late, and its severity is not dependent on the severity of the primary disorder.

Prophylaxis.—The infant mortality from diarrhœal disease of any city is in direct proportion to the ignorance of its inhabitants. As our knowledge of the etiology of these diseases has increased, it has brought with it increased possibility of prevention. In the last decade the infant mortality returns of most of the large cities in America show a definite downward tendency, due to better preventive methods being adopted on a large scale, and to improved methods of diagnosis and treatment.

Much can be done in the way of prevention by improving the general hygienic surroundings of children. In cities with overcrowded tenements and dirty streets these diseases flourish as soon as the heat of summer makes itself felt.

It is the duty of all civic health boards to provide open spaces or parks where children may play in the fresh air. These parks should be kept clean, and shelter should be provided by means of trees or pavilions from the direct rays of the sun.

Inspectors should be appointed whose duty it should be to visit houses in the crowded parts of the city and see that they are properly ventilated and hygienically satisfactory. By means of these inspectors pamphlets may be distributed giving information as to the proper care and feeding of infants and children during the hot season. In these pamphlets it should be made very clear that dentition is not a cause of diarrhœa, and that looseness of the bowels in infants is not a beneficial but a harmful condition, and should receive prompt attention.

The milk supply of all cities should be under the direct control of the civic board of health, and nothing is better established than the relation of impure milk to the causation of diarrhœa. It is not sufficient to enact that milk shall be confiscated and the vendor punished, when it is below a certain standard of food value. Of quite as much importance as the percentage of total solids and fats is the percentage of dirt which may be present.

The number of bacteria per cubic centimetre in milk indicates very clearly the amount of dirt present. Milk that contains under 10,000 bacteria per cubic centimetre may be accepted as pure milk and fit for infant feeding. Bitter claims that the maximal limit for milk that is fit for food is 50,000 bacteria per cubic centimetre. Dr. Turner in examining one hundred and seventeen samples of milk in Washington found only fifty-two to contain less than 50,000 bacteria per cubic centimetre; and some of the samples contained a higher number of bacteria than the sewage water of the city.

Hence the importance of milk inspectors in every city, whose duty it should be to examine the milk and inspect the dairies, the cattle, and the methods of caring for and transporting the milk.

In many cities noble philanthropic work has been done, which has been of incalculable value, in providing the poor with a pure, clean milk at the same price ordinarily paid for an inferior article.

In warm weather particular attention should be paid to the care and preparation of the infant's food. All utensils employed in the preparation of the food should be sterilized by boiling daily. When possible the day's supply should be prepared in the morning and kept on ice. When possible a separate bottle should be provided for each feeding, and into it the proper amount should be put as soon as prepared. These should be stopped with sterilized cotton, care being taken to wipe the mouth of each bottle dry before corking. All nipples should be scrubbed and boiled daily and should be kept, when not in use, in a saturated solution of boric acid or else in a solution of bicarbonate of soda one drachm to the pint.

During the summer season it is a good general rule to give infants as little food as possible. A more dilute food and a longer interval between feedings than in cold weather will be found to give the best result.

Plenty of sterilized water should be supplied in warm weather as the infant is far more likely to be thirsty than hungry.

Over-feeding, too frequent feeding, and the use of improper foods are important dangers to the infant in warm weather.

Prompt attention should be given to all slight gastroenteric derangements in warm weather. A water diet for a few hours and a gradual return to the ordinary food, may be all the treatment necessary to ward off an impending attack of diarrhœa.

The sterilization of milk by heating it to a temperature of 100° C., although it destroys all bacteria, is to be avoided, as by such a process the value of the fluid as a food is greatly depreciated, and it is also altered in taste and smell.

When a perfectly pure milk can be obtained it is better employed raw, but as this is rarely possible in large cities, it is much safer to pasteurize it. This may be accomplished by heating to 60° C. (140° F.), at which point it should be kept for fifteen minutes, when the vessel containing it is to be placed on ice. This process, according to Russell, kills from 98 to 99.8 per cent. of all bacteria present in milk, without interfering in any way with the value of the fluid as a food.

Treatment.—*Hygienic Treatment.* In all cases of summer diarrhœa fresh air is of the greatest importance. The patient should be kept out of doors, in the coolest and shadiest spot available. When this is not possible, the sick-room should be cool, airy, and not too bright. Quietness is essential, for the little patients are frequently highly nervous and irritable.

The patient should be left alone as much as possible in cot, cradle, or perambulator, and should not be handled or petted.

If the attack does not yield to the treatment employed, the child should be removed to the seaside or mountains, after the most acute symptoms have been controlled, more good often being accomplished by a change of air than by all other means.

The clothing should be of the lightest material, a single long gown of thin flannel being the most suitable garment. If there is much perspiration a thin linen or cotton gauze under-vest may be worn next the skin. The clothing should be so arranged that it may be removed without disturbing the child, and should be changed whenever soiled.

The sick-room should be kept scrupulously clean and free from dust. All soiled clothing and diapers should be removed from the room immediately. The diapers should be placed in a disinfectant solution for some hours before being washed and boiled.

Bathing is valuable in that it allays restlessness and reduces the temperature of the patient. To insure cleanliness the child's body may be sponged with alcohol and water several times daily, but when it is desired to reduce the temperature the cold pack or tub bath should be employed.

When the body temperature is high and the extremities feel cold, the writer prefers the cold pack. (1) The mattress of the bed or cradle is to be protected by a rubber sheet or oilcloth over which is laid a small blanket; (2) an ordinary large towel is then wrung out of water at a temperature of 70° F. and wrapped about the child's body and arms, reaching down to about the knees. A hot-water bottle is applied to the child's feet. Cold water may be sprinkled from time to time on the towel without removing it from the child's body. To increase evaporation the child should be briskly fanned while it is in the pack. The patient may remain in such a pack for from fifteen minutes to an hour. As soon as the body temperature has been sufficiently reduced the pack may be removed, and the child put into fresh, dry clothing with as little disturbance as possible.

The temperature of the bath, when this means is employed to reduce the fever, should be about 100° F. when the child is put into it. When possible a small child's bath should be used, and it should contain sufficient water to cover completely the body to the neck. The temperature of the water in the bath should then be reduced to 80° or 85° F. by adding ice. While the child is in the bath its head should be supported by the nurse, and its body should be briskly rubbed so as to promote the circulation. The child should remain in the bath for from ten to thirty minutes, according to the requirements of the case. The child's temperature should be tâken by placing the thermometer in the rectum five minutes after it has been removed from the bath.

Properly and carefully given, a cold bath should not frighten or exhaust the little patient.

The bath or pack is indicated when the body temperature rises above $102\frac{2}{5}$° F., and it may be repeated as often as required to control the temperature.

Excoriations of the buttocks and genitals should receive careful attention. The parts should be washed with weak bicarbonate of soda solution, carefully dried with cotton wool or soft linen, and then dusted with borated talcum, simple starch, or stearate of zinc.

Dietetic Treatment.—In all forms of acute diarrhœa in infancy food should be entirely withheld during the early stage. Digestion and assimilation are practically arrested at this time, and food, instead of being of assistance to the patient, can only work harm.

For the first twenty-four hours boiled water, in the quantity of one or two ounces, to which a pinch of salt, or a little milk sugar has been added, may be given at intervals of one or two hours. The object of the dietetic treatment is to supply the simplest nourishment in suitable quantities and at regular intervals, in order not to excite gastro-enteric irritation.

Milk should be entirely withheld in all cases.

The foods selected should be those which require the least effort to digest, and which leave the minimum amount of residue. The quantity should be the minimum possible, and it should be repeated at intervals which will insure periods of entire rest to the stomach.

The return to the ordinary diet should be slow and carefully regulated.

Explicit directions in regard to the various details of treatment should be given to the nurse or attendant in writing. Food prescriptions should be made out with the same care and attention that is usual in the ordering of drugs. The quantity, quality, and frequency of administration should be carefully set down so that no mistake can arise.

The difficulty generally is to find a suitable article of diet that the patient will like and take well. In order to be successful the resourceful physician will have a list of suitable foods which may be tried one after the other, until one is found which is acceptable to the child under treatment.

In general, the quantity of nourishment at each feeding should be from one-fourth to one-half the amount given in health, according to the tolerance of the stomach.

The interval between feedings should be as lengthy as possible. It is seldom necessary to nurse or feed a sick child oftener than every two hours. No effort should be made to feed by the mouth until gastric irritability has been controlled and no vomiting has occurred for six or eight hours.

Nurslings after a short period of starvation, at least twelve hours, may be put to the breast for two or three minutes. Nursing may then be permitted every four hours. Between the nursings whey, or sugar-of-milk solution (five per cent.), may be given, so that the infant is fed every two hours.

Before permitting the child to be put to the breast, the mother's milk should be examined, provided there be any reason to suspect that its composition may disagree with the patient.

The problem of supplying a suitable artificial food to infants under five or six months of age, who have been the subjects of diarrhœa, is one of the most difficult the physician has to solve. But of recent years this problem has been much simplified by the establishment of properly managed milk laboratories in several of the large cities. Even under the best of circumstances, in hot weather the difficulties are almost unsurmountable; hence when possible a suitable wet-nurse should be secured for these cases.

After the period of "water diet" the question to be decided is whether to use albuminous or farinaceous fluids. It is the habit of the writers to employ farinaceous fluids when the motions are particularly foul, and the abdomen of the child is distended with gas. When these conditions are not marked, resort may be had to dilute broths, and other albuminous fluids, such as albumin water, liquid peptonoids, and panopepton.

The farinaceous fluids may be made from barley, rice, oatmeal, tapioca, sago, corn starch, arrowroot, or flour ball. It is important to boil these foods for at least three hours so as to prevent trouble from indigestible starch. These fluids should be given cold or just slightly warmed, and the younger the child the more dilute should the fluid be. It is important in all cases to strain farinaceous fluids before using them.

One of the best and cheapest foods of this class is the old-fashioned flour ball. This is prepared as follows: Take one pound of good wheat flour (unbolted if obtainable), tie it up very tightly in a strong piece of cotton, place in a saucepan of water, and boil constantly for ten hours; when cold remove the cloth and cut away the soft outer covering of dough. The firm central part is then to be grated down to a powder as required. A suitable quantity of this powder is then rubbed into a paste with water until a creamy mixture is obtained. To this a sufficient amount of water is added to make the quantity required for a feeding, and then boiled for fifteen minutes.

The albuminous food substances should always be well diluted; as they do not keep well, they should be prepared only in small quantities.

Albumin water is prepared by squeezing the white of one egg through a piece of sterilized gauze into a teacup full of boiled cold water. To this may be added a small quantity of sugar and a pinch of salt, and when necessary a teaspoonful or two of good whiskey or brandy. Chicken broth and veal broths are also extremely useful. These may be reduced to a jelly, of which a small quantity may be added to any of the farinaceous fluids, as required. The juice of rare beef, expressed by means of a meat press, may be employed, diluted in the proportion of one part of the beef juice to ten parts of water, or any of the farinaceous fluids. Liquid peptonoids or panopepton may be employed diluted in the same proportion as the beef juice.

The return to a milk diet should not be attempted until several days after the motions have become normal. It may be begun by adding one teaspoonful of cream to the farinaceous fluid the patient is receiving. If this gives rise to no distress, the quantity may be gradually increased. When modified milk is employed the fat and the casein should be greatly reduced. To begin with, a formula of fat 1%, sugar 6%, proteid 0.5%, may be tried. This should be predigested in the case of infants under four months. If it is well borne the constituents may be gradually increased. Instead of using sugar solution in the modified milk mixture, it may be replaced by thin barley or rice water.

The same general principles apply to the feeding of older children. Kumyss or matzoon may be allowed before milk is given.

After an attack of entero-colitis the diet should be carefully regulated for months, as relapses are very easily excited by improper articles of food. Oatmeal, potatoes, tomatoes, corn, and all kinds of fruits should be forbidden.

The abdomen should be protected by wearing a flannel binder, even at night, as sudden changes of temperature are to be avoided. Fatigue, exhaustion, and nervous strain of any kind are liable to excite a recurrence of the malady.

In chronic diarrhœa the diet most suitable is that employed in the later stages of acute cases. Albuminous articles are to be preferred, and starches and fats avoided, or given in small quantities, the effect of these on the stools being closely watched.

Medicinal Treatment. Purgatives: The first indication of medicinal treatment is to evacuate the entire digestive tract.

The initial vomiting may have cleared the stomach more or less efficiently. If this is not the case, some simple emetic, such as ipecac or zinc sulphate, may be employed in older children, but in infants nothing is more efficient than stomach washing. If this be impossible, large draughts of water should be administered and the vomiting reflex excited by tickling the fauces.

The colon may be emptied by irrigation, but to clear the small intestine cathartics must be resorted to. The best for this purpose are castor oil and calomel.

When vomiting is not marked castor oil should receive the preference, as its results are fairly prompt and certain, and its after-effects soothing. The proper dose is one drachm to a child under six months of age, two drachms to one a year old, and half an ounce to one over three years of age.

If vomiting is a marked initial symptom calomel should be employed. Two grains may be given at one dose, or better, gr. ¼ every hour up to eight doses or until the characteristic green motions are seen. This has a favorable effect upon the vomiting, and is valuable both as an antiseptic and as a purgative.

If the motions occur with great frequency and are fluid, all purgatives should be avoided, stomach washing and colon irrigation taking their place. It is necessary to wash the stomach out only once as a rule, but the colon should be irrigated several times daily.

Antiseptics and Astringents: The value of intestinal antiseptics in diarrhœas of infancy is open to question. The writer cannot claim any great faith in those he has employed. Salol, resorcin, the sulpho-carbolates, carbolic acid, salicylate of soda, and several others have all given equal satisfaction. Salol and resorcin in gr. i. doses every three hours to a child six months of age have the preference.

But of all drugs the most useful in the diarrhœas of infancy is undoubtedly bismuth. Most of its preparations can be given in fairly large doses and rarely cause vomiting if properly administered. The most satisfactory preparations are the subnitrate, the subgallate, and the salicylate. The subgallate of bismuth may be given in doses of from gr. ij. to iv. every two hours to a child a year old. The salicylate may be given in doses of gr. i. to ij., with the same interval to a child one year old.

Bismuth subnitrate is probably the most reliable preparation; it may be given in doses of gr. v. to x. every two hours to a child a year old. It has been combined with the salicylate with advantage in the writer's experience, and is best administered suspended in mucilage, sweetened with glycerin. It should be given in sufficiently large doses to blacken the stools and often enough to keep them of that color.

The objection to salicylate of soda and also to salol is that they tend to cause vomiting., The action of salol upon the kidneys should be closely watched when large doses of this drug are employed.

Arsenite of copper is useful in the later stages after the temperature has fallen and the stools are no longer offensive. It may be given in doses of gr. $\frac{1}{200}$ every three hours to a child a year old.

Tannigen in doses of gr. iij. every three hours in a child a year old is useful, especially when the diarrhœa tends to become chronic. Excellent results have been reported from the use of tannalbin, but the writers have had no experience of its employment.

Acids: Dilute hydrochloric and sulphuric acids are of distinct value in chronic cases. They are best administered in combination with some digestive, as lacto-peptine, shortly after food. The dose is from ♏ ss. to iij., according to the age of the patient.

Alkalies are of value in cases in which the stools are strongly acid and cause excoriation of the buttocks and genitals. They tend to alleviate vomiting, and are particularly serviceable in acute cases. The most valuable are lime water, magnesia, sodium bicarbonate, and chalk mixture.

Opiates: Opiates in some form are required in many cases, particularly those in which tenesmus, pain, and great frequency of motions are marked.

Opium in any form should be withheld until the intestinal canal has been cleared by purgatives or by irrigation; it should not be given when there are cerebral symptoms, associated with scanty, offensive motions. It is of service, however, in those cases in which the administration of food is followed by active peristalsis and frequent stools.

Opiates should always be administered alone and not in combination with diarrhœa mixtures, and their effect on the number of the stools should be noted and the dose and frequency regulated accordingly.

The best preparations are paregoric when it is to be administered by the mouth, and the liq. opii sedativus (Battley) when given in an enema.

When paregoric is used it is best to give small doses at short intervals till the desired effect is produced. For a child of one year the initial dose should be ♏ v., to be repeated every one, two, three, or four hours as may be indicated (Holt). Dover's powder is particularly suited to certain cases, but its taste is objectionable. It may be given in doses of gr. ¼, to a child one year old, every one, two, or three hours as required. Laudanum or Battley's solution may be given in doses of ♏ i. to iij. in an enema consisting of ℥ iij. of thin starch solution, and may be repeated as often as necessary in order to control tenesmus and pain.

The severe tenesmus occasionally associated with prolapsus ani, met with in acute ileo-colitis, is best relieved by means of a suppository containing cocaine, in the dose of from gr. ¼ to i., according to the child's age.

Stimulants are needed in a great many cases, but are often used unwisely. Alcohol stands at the head of the list. It is best used in the form of good whiskey or brandy. The daily quantity should rarely exceed from ʒ ij. to iv., and is best administered well diluted with sterilized water or albumin water.

In chronic cases wines, particularly claret and hock, are of distinct value. Other stimulants are aromatic spirits of ammonia, and caffeine in the form of cold tea or coffee.

In *cholera infantum* the condition of intoxication is usually so severe as to demand the most urgent and active treatment. The main indications are: (1) to clear the gastro enteric tract; (2) to support the heart and nervous system; (3) to reduce the temperature; and (4) to supply the tissues with fluid to compensate the drain of the discharges.

The first indication is best fulfilled by lavage of the stomach and irrigation of the colon.

As the absorptive processes are at a standstill in the stomach and intestine, hypodermic medication must be relied on to control the action of the toxins on the heart and nervous system. For this purpose a hypodermic injection of morphine, gr. $\frac{1}{100}$, and atropine, gr. $\frac{1}{800}$, may be given to a child a year old, and repeated every hour till the desired result is obtained. The only contraindication of the morphine is stupor associated with scanty purgation.

To replace the watery drain, intracellular injection of normal saline solution is indicated. Half a pint of a solution of salt in sterilized water may thus be injected into the cellular tissue of the abdomen, buttocks, thighs, or back.

To reduce the temperature the cold bath only can be relied upon. It must be repeated as often as required to keep the temperature within bounds.

Ice-cold water irrigation of the colon is also of great service in reducing the temperature, and the ice cap should always be employed.

Stimulants may be administered hypodermically if the vomiting is severe. Whiskey, ether, or camphor may be used freely as indicated.

David James Evans.
F. Morley Fry.

DIASTASE.—An unorganized ferment, or enzyme, occurring in plants, especially in seeds during germination, and possessing the function of converting their starch into sugar (maltose and dextrose). The diastase of barley and its relatives is best known. It is the agent which converts the starch into sugar in the manufacture of malt. It is not present, or at least not in appreciable quantity, until germination occurs, when it is developed from some other body present. Its amount increases up to a certain stage of germination, when it begins to decrease. When at its height, it is equal to about one-fifth of one per cent. of the original weight of the seeds. Like other enzymes, it does not combine with the substance upon which it acts, and is not itself consumed in the process, except by the application of undue heat (above 125° F.), and is still present in the malt. The several forms of extract of malt upon the market, either so-called or sold under fanciful copyrighted names, contain various amounts of it. The extensive use of diastase, for both external and internal starch digestion, has led to a strong demand for its introduction into the Pharmacopœia, a demand which is likely to be complied with.

Pure diastase, like pure pepsin, is unknown, but the substance known to us under this name is a white, or at most pale yellowish, odorless and tasteless powder, soluble in water and weak alcohol, but precipitated by strong alcohol. Albuminous matter and sugar are its common impurities. The readiness with which it digests starch under artificial conditions suggests its ability to do so in the stomach during the early stages of digestion, before it is destroyed by the free acidity of the gastric juice, and experiment has demonstrated that such is the case. Diastase is readily subject to standardization, but all the processes are tedious and rather complicated. They depend upon the power of a standard diastase solution to digest a certain amount of starch within a specified time, under fixed and carefully regulated conditions. It is to be remembered that their only value for determining the relative activities of different samples of diastase lies in the rigid uniformity of the conditions of trial. No statement that a certain diastase or diastasic substance converts a certain amount of starch, as contrasted with some other, is of the slightest value, except upon this condition. The dose is 0.1 to 0.6 gm. (gr. ij. to x.), and it must be taken with the meal, preferably during the latter part, or just at its close, when the hydrochloric acid, having entered into combination with the proteids, cannot inhibit its action. *Henry H. Rusby.*

DIASTASE, TAKA.—Taka diastase is diastase found "crystallized" upon the roots of certain species of *Aspergillus* and removed in water. The removal of diastase from various species of fungi for use in the production of fermented liquors has long been in vogue in Japan. Some years ago Dr. Jokichi Takamine studied the effects of these substances and selected that derived from the above species for medicinal use. He named it as above because "taka" means *strong* in Greek, *high* in Japanese, and forms the first part of the name of the investigator. The method of production is thoroughly to sterilize wheat bran, and to sow it with a pure culture of the spores of the *Aspergillus*. After about fifty hours' exposure to a warm and moist atmosphere, there is an abundant crop of the fungus, which then bears its highest percentage of diastase. If left longer, the diastase would be consumed. The mass is now quickly cooled, broken up and percolated with cold water. The percolate is evaporated in a vacuum pan to a syrupy consistence, this liquid being ten times as strong as ordinary malt. From it the diastase is precipitated by strong alcohol, removed, and dried in the form of a yellowish white, odorless powder of pleasant taste. Under the most favorable conditions, it digests three hundred times its own weight of dry starch, or ten times as much cooked bread or other similar starchy food. Under ordinary conditions it digests from one hundred to one hundred and fifty times its weight of dry starch. Experiment has fully demonstrated that a similar result takes place in the stomach during the first hour or two of digestion. It is even believed by some that it can pass through the stomach and continue its work in the duodenum, but undoubtedly its principal work is performed in the stomach, as stated. By encasing it in keratin capsules or pills, it can be made to pass through the stomach and be freed for work in the duodenum. The ordinary dose is gr. iiss. It should be taken immediately with the meal.

Henry H. Rusby.

DIATHESIS.—In proportion to our increase in knowledge of the etiology and pathology of disease does the tendency to use the words idiopathic, dyscrasia, and diathesis grow less. Text-books and dictionaries which antedate the acceptation of the germ theory are filled with these terms, while the authoritative works of to-day seldom use them except in connection with those diseases concerning which our knowledge is still very limited, as, for instance, the uric-acid diathesis. Even this most beloved of the diatheses is now often replaced by lithuria and lithæmia. A few decades ago, were a man to develop any one of a host of diseases, it was explained by the fact that he was the unfortunate victim of a peculiar diathesis.

In Foster's Medical Dictionary reference is made to nearly seventy varieties of diatheses and more than twenty varieties of dyscrasia. A verminous diathesis is described as a constitutional condition that has been assumed to favor the development of intestinal worms. Such expressions as bilious diathesis, congestive diathesis, and basic aural dyscrasia indicate the earlier uses of these terms.

Previous to the discovery of the tubercle bacillus cases of consumption were usually explained by the hereditary and diathetic theory. We now know that the most robust, who have not the slightest tendency to tuberculosis, when thoroughly exposed to the infection may develop the disease. However, we must keep in mind the importance of the phthisical habit in connection with its development. Persons of this habit are not already tuberculous, but have tissues which are more vulnerable, less able to resist the attacks of these omnipresent germs. Exposure to infection, rather than the presence of a special diathesis, is in many instances the explanation of the development of disease.

The words diathesis, dyscrasia, and idiopathic have served for many years the purpose of cloaking our ignorance. However, their mission is yearly becoming more limited.

Diathesis and dyscrasia have frequently been used as synonyms meaning predisposition. In many instances diathesis has been used in the sense of disease, but the most commonly accepted meaning of the word is that of predisposition or habit of body. By dyscrasia is meant a cachectic condition which has resulted from the action of certain diseases upon the system. The cancerous diathesis means a hereditary tendency toward the development of cancer, while by cancerous dyscrasia is meant a cachectic or diseased condition of the system which has resulted from the presence of cancer and the absorption of toxins manufactured by the carcinomatous growths.

In a very limited way the word diathesis is still used by modern authors. The following are the diatheses which still cling to our text-books: The uric-acid diathesis, though a common expression, conveys very little information. It is held by many physicians to be responsible for numerous indefinite symptoms. It is supposed to be due to faulty metabolism, which if long continued may lead to gout, with uric-acid deposits in the joints, acute inflammations, and arterial and renal disease.

The expression gouty diathesis is practically synonymous with uric-acid diathesis. It represents the underlying condition of the system which is inherited by those who come of gouty stock or which is acquired by *bon vivants* prior to the characteristic arthritic manifestations of the disease.

The tuberculous or scrofulous diathesis is mentioned by many authors. By it should be meant the inheritance of tissues which are less resistant than normal to the action of the tubercle bacillus.

Hemorrhagic diathesis is the synonym of hæmophilia and indicates a peculiar constitutional condition in which the patient is prone to hemorrhages.

The part played by heredity in its relation to disease, though greatly limited by the advances of our knowledge in recent years, must not be underestimated. There exists a close relationship between diathesis, used in the sense of predisposition or tendency, and heredity.

It would seem wise and in keeping with the spirit of the age to eliminate as much as possible from our vocabulary the words diathesis and dyscrasia, and substitute for them words which will never become obsolete, viz., predisposition and cachexia. *James R. Arneill.*

DIAZO REACTION OF EHRLICH. See *Typhoid Fever* and *Tuberculosis.*

DIETETICS OF THE SICK.—The proper adjustment of food for the individual in health yields results, in the form of work and physical well-being, that will fully reward the dietetic care exercised. Man has at his disposal a greater variety of foods than any other animal. The methods pursued in the preparation of the food will greatly modify its taste and digestibility.

A *food* is any substance which can be utilized in the living organism for structural or functional purposes.

A *complete food* must contain all of the substances necessary to construct and maintain the activities of the tissues of the body. Thus, while meat furnishes us food in concentrated form, it is a simple and not a complete food. Milk is composed of the elements necessary to construct and maintain the human economy. Such a food must contain water, mineral matter, nitrogenous matter, carbohydrates, and fats. It is not enough that a substance possess these elements in order to be regarded as a complete food, but it must possess them in assimilable form and of such a character that sufficient for nutritive purposes may be ingested. The food required for twenty-four hours by a healthy individual weighing one hundred and fifty-four pounds, and doing moderate work, should contain the following elements:

	Pounds.	Ounces.	Grains.
Water	5	8	320
Albuminoids	0	4	110
Starch, sugar, etc	0	11	178
Fat	0	3	337
Common salt	0	0	325
Phosphates, potash, salts, etc	0	0	170

The individual in health gives little heed to proper combinations of food elements and the intake of nourishment sufficient to secure a condition of nutritional equilibrium. It is only when the viscera concerned with the elaboration and utilization of food have been disordered by the ingestion of an excess, or of unsuitable food, that dietetic measures are considered.

The problem of adjusting the food to the requirements of the individual in health is most complex; the adaptation of the dietary to diseased organs is yet more complicated.

In disease there is an increased need for food, and a lessened ability to digest it. The demand for nourishment will be influenced by the character of the morbid process. Thus there is a wide range of variation in combustion of nutritive material between the individual who is confined to bed with an acute local inflammation, and one who is subject to an acute infectious disease or a chronic suppurative process. The perverted secretions and functional inactivity associated with certain diseases render it impossible to secure the ingestion and metabolism of sufficient nourishment for the production of the heat incident to the disease. The circulating albumin, the fat, the muscular tissue, and finally, the viscera themselves are drawn upon to furnish the needed food elements for the morbidly active combustive process. One has only to look on the feeble, emaciated convalescent from an acute febrile disease, and to contrast his condition with the previously muscular, rounded form, to realize the extent to which the body consumes its own tissues when it is unable to elaborate and annex other forms of food in the necessary quantities. The intake of food is intermittent, while the necessity for nutriment to maintain the increased activity of this vital process is constant. This condition would indicate the desirability of administering nourishment, in assimilable form, in small quantities and at frequent intervals, since it is not what we eat but what we digest and assimilate that determines the sufficiency of any dietetic procedure.

The appetite and digestion will usually furnish a sufficiently reliable guide to regulate the character and quantity of food to be taken in health. In disease, with a perversion of the various secretions, it is not prudent to rely upon the patient's desire or disinclination for food.

The administration of food in disease will be determined by our estimate of the ability of the digestive organs to dispose of it. A temporary withholding of food in certain instances of acute disease will be the best dietetic treatment. The administration of what would ordinarily be an excessive quantity of food is advisable in certain chronic suppurative processes attended with fever. Since the digestive juices are influenced by the absence of fever, it is advisable to administer foods requiring the greatest digestive power at that time of the day when the fever is least active.

It is possible still further to adjust the proper administration of food with reference to existing morbid conditions by observing the rule to select the food with regard to the affected part. Thus, in disease which particularly involves the stomach, it would be best to give food whose digestion is accomplished in the intestines, *i.e.*, carbohydrates. The converse is equally true. When the intestines are the seat of the morbid process, a food requiring gastric digestion would prove most acceptable. This differentiation is not absolute, and yet it is reasonable and serviceable.

The dietetic treatment of disease may be planned with skill and care, and yet prove inefficacious because of a disregard of two essential factors in the successful administration of food. Dainty service may be given first place. All that can be pictured as implied by the expression will prove helpful in stimulating and aiding digestion. The glass of milk placed beside the spit-cup of the consumptive patient is not novel, neither is it appetizing. The cereal carelessly smeared over the sides and edges of the container, and served in a quantity sufficient for a laborer, is seen more often than it should be. The food sent by a cleanly neighbor is appetizing because it is served with the best china and linen, and the question of its selection has not been discussed with the patient.

Equally important is the preparation of the food. Egg albumen if slightly cooked is digested with the greatest facility. If well beaten it offers the digestive juices least resistance in their solvent action. The hard-boiled white of egg is an example of a food difficult of digestion. Roasted beef having a delicious aroma is far more digestible than the same meat when it is hashed and twice cooked. The chop quickly broiled, so that it retains its juices and is turgid, is more nutritive than the shrivelled and dried, slowly fried or broiled chop from the same cut of the lamb. The method of preparation of vegetables will determine their digestibility and nutritive worth quite as certainly as it does in the case of animal foods. Cereals with the starch cells unruptured by the application of heat or—equally difficult of digestion—cooked in hot fat after the starch granules have been exposed to the action of the over-heated fat, are not of much nutritive value. By the application of the proper amount of heat the cellulose element of certain vegetable foods can be made tender and digestible, and their nutritive worth may be secured instead of being lost between the meshes of the cellular fibres.

The ordering of diet will be simplified by keeping in mind the chemical composition of the various foods.

If animal food is to be made a part of the diet, it becomes necessary to select the form deemed suitable to the digestive power and condition of a given case.

If a vegetable food is to be used, it will be necessary to consider the proportion of nitrogenous or albuminous elements contained in it. We should select vegetables belonging to the class of legumes if a large percentage of nitrogenous material is desired.

In certain instances vegetable nitrogenous material properly prepared will be found better adapted to impaired digestive power than the animal form. If, on the other hand, food rich in carbohydrates and poor in albuminoids is desired, we should order vegetables containing the purer forms of starch, such as potatoes, rice, corn starch, and arrowroot. The green vegetables, being poor in starch and nitrogen, and rich in woody fibre and antiscorbutic elements, are selected with reference to the need and ability of the patient to digest this form of food.

Condiments should be used extensively and judiciously, being more important in sickness than in health. Tea, coffee, cocoa, and chocolate are valuable agents, combining as they do food and therapeutic worth.

The method of preparation of the various foods exercises a determining influence upon their utility. It is not enough to select the foods that may be used in a given instance, but detailed directions, with reference to the method of preparation, must be supplied. A great variety of foods at one meal may prove unsuitable to certain cases, while a meal composed of a sufficient variety of food principles to constitute a complete food, may be found to be easily digested. A meal made up of several kinds of meat and one or more legumes is likely to contain an excess of nitrogenous food. It will probably serve best the purpose in view to consider at this time the chief alimentary substances, and some of the ways of administering them, and in this way avoid the necessity for repeating certain statements when directing the employment of these food agents in the dietetic treatment of disease.

MILK.

This food is the chief article of diet in feeding the sick, and by reason of its availability and the likelihood of its being moderately pure, it is relied upon to supply the nutriment required in almost all forms of disease. When we consider how nearly it is *the ideal complete food* for the invalid, it is in order to give thought to all the means at our command to make it acceptable to the patient. There are those who persist in the idea that they are unable to take milk as a food. They point to the vomited curd as an evidence of their inability to digest it. These people must be taught the fact that the milk taken into the stomach always forms a curd as a necessary part of the process of digestion. Then they must be told that we can so modify the milk that the curd formed will be small and easily digested. Other patients will object to the taste and odor of the milk. These objections must be overcome by a knowledge of *the ways in which milk can be made acceptable* to a patient.

Let us consider the chemical composition of milk and see what constituents may disagree with the patient. Cow's milk has the following composition:

	Per cent.
Casein	4
Fat	4
Sugar	4.50
Bacteria	—
Salts	0.8
Water	86.7

It is the casein that most frequently taxes the digestion by reason of the size and density of the curd formed. Therefore the question of successfully administering milk in most instances is one of modifying the curd, so that it may be digested with greater facility.

The fat constituent of milk, represented in the cream, is less frequently a disturbing element in the use of milk as an exclusive diet. The indications for reducing the proportion of fat in the milk would be presented by disease or perverted function of the organs concerned in digesting and assimilating fat, that is, in disease of the liver, as jaundice, and in certain cases of intestinal indigestion.

The presence of bacteria in milk greatly influences its acceptability in cases of sickness. One difference between cow's milk and human milk is found in the number and character of the contained bacteria. The method pursued in handling milk from the time it leaves the cow, if not before that time, will determine the number and character of the bacteria present. There is hardly any doubt that the objections to milk are chiefly due to the presence of bacteria and their products. When we remember that the number of bacteria in a given milk is proportionate to the skill and care with which it is handled, it is at once manifest that we are justified in demanding that the milk supplied should conform to certain reasonable tests. I cannot do better than submit the standard of purity exacted by the Philadelphia Pediatric Society of those who would derive the advantages of the certificate of the Society for the product of their dairy. The tests are the result of much study on the part of the Society's committee, and while it fixes a high standard, it has proved to be a working standard, and one that can be obtained only by the most painstaking care with every detail of the processes of feeding, milking, and bottling.

Articles of Agreement entered into the....................day of.........., 190.... between the Milk Commission of the Philadelphia Pediatric Society of the first part and............................ of the second part.

It is agreed by the said parties that these articles of agreement shall continue for a period of eight months from date.

The party of the second part agrees that the party of the first part shall procure a bacteriologist, a chemist, and a veterinary inspector; the bacteriologist to procure a specimen of the milk either from the dairy or delivery wagon of said party of the second part, whenever the said party of the first part sees fit, at intervals of approximately one month, the time of procuring said milk to be without notice to the said party of the second part; which bacteriologist shall test said milk for the number and nature of bacteria present to the extent which the needs of safe milk demand, and to make a microscopic examination for pus cells and injurious germs. It is also agreed by the parties hereto that the required standard of purity shall be milk free from pus or injurious germs and having not more than ten thousand germs of any kind or kinds to the cubic centimetre.

It is agreed by the said party of the second part that the chemist of the party of the first part shall examine said milk for the percentages of proteids, fat, sugar, mineral matter, and water present; shall test its chemical reaction and specific gravity; and shall examine it for the presence of foreign coloring or other matters or chemicals added as preservatives. It is agreed by both parties that the required standard shall range from 1.029 to 1.034 specific gravity, be neutral or very faintly acid in reaction, contain not less than from 3.5 per cent. to 4.5 per cent. proteid, from 4 per cent. to 5 per cent. sugar, and not less than 3.5 per cent. to 4.5 per cent. fat (a higher percentage in fat to be so specified on each bottle), and shall be free from all contaminating foreign matter and from all additions of chemical substances or coloring matters; that richness of cream in fat shall be specified and shall vary not more than 1 per cent. above or below the figure named, and that neither milk nor cream shall have been subjected to heat before the examination nor shall be at any time unless so announced to the consumer.

It is agreed by both parties that the veterinary inspector shall at intervals equal to those of the bacteriologist and chemist, and without previous warning to the party of the second part or his agents, inspect the cleanliness of the dairy in general, the care and cleanliness observed in milking, the care of the various utensils employed, the nature and quality of the food used, and all other matters of a hygienic nature bearing upon the health of the cows and the cleanliness of the milk, including as far as possible the inquiry into the health of the employees on and about the dairies; and that he shall see that the cows are free from tuberculosis or other diseases.

It is also agreed by both parties that charges shall be made by each of the experts not to exceed ten dollars for each examination, which amount is to be paid by the party of the second part at the time of examination and without reference to whether the report is favorable or otherwise.

It is agreed that all examinations by the experts shall be made only upon instruction by party of the first part.

It is agreed by both parties that if examinations as aforesaid find the milk up to the aforesaid required standards, the said party of the first part shall give a certificate to said party of the second part as follows:

MILK COMMISSION OF THE PHILADELPHIA PEDIATRIC SOCIETY.

Date............................

The Veterinary Inspector of this Commission has examined the dairy of.., and reports it to be well kept and clean and the cows to be in a healthy condition.

The Bacteriologist reports the milk free from germs within the limits of the standards of the Commission.

The Chemist reports that the milk is of standard richness and that he has discovered no impurities, coloring matters, chemical preservatives or harmful substances.

The Commission certifies to these statements of the Examiners, it being understood, however, that this certificate is good for only one month from date.

....

It is further agreed by both parties hereto that in case an examination shows the milk not to be up to the required standard that said party of the second part may have another examination made within a short time at the direction of the Commission.

It is agreed by the party of the second part that the milk furnished by him to dealers shall be in glass jars hermetically sealed in a manner satisfactory to the party of the first part, and as a guaranty to the consumer that the examination has been regularly conducted, he shall paste over the mouth of each jar or give to the consumer with every jar a label similar to the following:

MILK COMMISSION OF THE PHILADELPHIA PEDIATRIC SOCIETY.

Date.............................

Milk from the dairy of............ .... has been recently examined by the Inspectors of this Commission and found of the required standard.

This certificate is good for only one month.

Milk Commission of the Philadelphia Pediatric Society.

It is further agreed by the said party of the second part that this agreement is entered into by the parties hereto solely at the request of said party of the second part; that no liability shall accrue to said party of the first part except or beyond that expressly stated in these articles of agreement; and that he the said party of the second part will assume all risk and be liable for any complaint alleged to be traceable to the examinations, issuance of certificate, and labels aforesaid.

In testimony whereof the parties hereto have hereunto set their hands and seals the date aforesaid.

MILK COMMISSION PHILADELPHIA
[SEAL] PEDIATRIC SOCIETY.

Milk secured under these conditions will keep for a longer period than that collected in the usual way.

It is interesting to note that fermentation changes in milk proceed from the surface toward the bottom of the container. So markedly is this the case that it is frequently possible to pass a tube through an upper layer of thick, sour milk and draw off sweet milk until only the layer of thick milk remains. This condition implies that the milk was practically sterile when bottled, and that the souring has been due to a later entrance of bacteria.

Pasteurization of milk is accomplished by subjecting it, by means of a water bath, to a temperature of 167° F. for a period of thirty minutes.

Sterilization of milk is accomplished by the same method followed in Pasteurizing, except that the temperature to which the milk is subjected is 212° F.

Both methods have for their object the destruction of harmful bacteria. The consensus of opinion would seem to justify the statement that Pasteurization will accomplish all that can be attained by sterilization, and that it has the advantage of impairing the digestibility and the nutritive worth of the milk less than does the higher temperature. Infants fed upon sterilized milk are more likely to develop rickets and scorbutus than are those raised upon Pasteurized milk.

There are numerous outfits in the market for the sterilization and Pasteurization of milk, and with each of them will be found directions for use. If the patient is unable to procure one of the more pretentious devices for this purpose, he can accomplish the object by placing the milk in bottles of suitable size, plugging them loosely with sterile cotton, standing the bottles in a kettle on a plate, piece of thin wood, or folded paper, and filling the kettle with cold water to a point on a level with the milk in the bottles. The water is then heated until it reaches the boiling point, and if the kettle is then removed to the back part of the stove, or the gas flame is lowered so that a temperature slightly below the boiling point is maintained, the milk will be Pasteurized in thirty minutes. If it is desired to sterilize the milk, the water should be kept at the boiling point for the time specified. The milk should be cooled rapidly and kept in a cool place. The keeping quality of the milk will be proportionate to the number and character of the contained bacteria.

Foreign Bodies in Milk.—An interesting object lesson in the *origin of the "cow odor" of milk* can be obtained by a visit to a creamery where milk, gathered indiscriminately from farms, is centrifuged. Here there can be seen thrown out from the milk a layer of excrementitious material that has gained entrance into the milk from the soiled teats of the cow, the dirty hands of the operator, and the dust of the shed or pasture. Milk that has been properly handled should have no odor.

The question of administering whole milk may present one of two problems: First, how to change the taste in order to make it acceptable to the patient; second, how to modify the curd so that the enfeebled digestive power may not be overtaxed by the size of the curd formed.

To change the taste it may be administered cold, hot, sterilized, boiled, or skimmed, or with the addition of coffee, tea, chocolate, malt, liquor, or a spiced water, the latter to be prepared by adding boiling water to cloves, ginger, nutmeg, allspice, cinnamon, or a few bay leaves, and allowing it to cool, then adding sufficient of this to the milk to change in a slight degree the flavor. These flavors can be changed at each feeding, or combinations of them may be used.

A satisfactory way to overcome the dislike of the taste of milk is to have it taken through a tube or a straw.

To modify the curd, have the patient *eat* the milk, that is, sip it slowly. If it is gulped down the curd formed will be large, especially if there is excessive acidity of the stomach contents. For this reason the use of a straw in taking milk is of advantage. The addition of an alkali to neutralize the excessive gastric acidity will lessen the size of the curd. For this purpose one may also use lime water or bicarbonate of soda. Simple dilution of the milk will make the curd smaller, and this may be accomplished by the addition of barley, rice, oatmeal, egg, or carbonated water.

When there is a deficiency of acid secretion, it will be of advantage to add dilute hydrochloric acid drop by drop to the milk and give it with the flocculent curd suspended.

With adults, just as with infants, it is the casein of the milk which most frequently taxes digestion. If we are unable to secure the retention of the milk by any of the methods considered, it will be in order to change the casein into a more digestible compound by peptonizing it to a point where its further digestion can be accomplished by the enfeebled gastric secretion.

Peptonizing Milk.—This is accomplished by mixing a powder composed of five grains of extract of pancreatin and fifteen grains of bicarbonate of soda, or the contents of a peptonizing tube, with two tablespoonfuls of cold water, and adding it to a pint of milk. The milk is then placed in a vessel containing water at a temperature of 115° F. (or so warm that the hand may be immersed in it without positive discomfort) for five, ten, or fifteen minutes, according to the degree of digestion desired. There is developed, in the course of the process, a bitter taste proportionate to the time the milk is subjected to the action of the ferment. After the milk has been peptonized to the desired degree, it should be placed upon ice or quickly brought to the boiling point to check further digestive action by the ferment. It will be found satisfactory in many instances to mix the milk and the contents of a peptonizing tube, and allow the peptonizing to occur in the stomach. For this purpose put two tablespoonfuls of cold water in a goblet or glass; dissolve in this the powder contained in one peptonizing tube, then add fresh cold milk to fill the glass; stir this mixture thoroughly and drink immediately, sipping slowly.* Warm milk may be used instead of cold if the physician so directs.

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* Acknowledgment is due to Fairchild Brothers & Foster for the formula.

The Administration of Milk.—There is no more important direction to be given to a patient than that milk should be taken slowly. If it is eaten, and not gulped, it will certainly be digested with greater facility. In many cases of persistent vomiting milk will be retained if it is fed by the teaspoonful at short intervals. If it is desired to nourish the patient on an exclusive milk diet, it is well gradually to lessen the variety and quantity of mixed food, and at the same time increase the quantity of milk. It might be a source of discouragement to the patient to announce the quantity of milk you desire to have him take to the exclusion of all other foods; therefore let the transition be gradual and make it a matter of pride with the individual to take the six or nine pints of milk that it is desired he should consume in twenty-four hours as his only form of nourishment.

As the condition changes and demands a less strict milk diet, the transition to a mixed dietary should be gradual. There will be manifest likelihood of harm being done to the circulation in any sudden withdrawal of so much liquid from the food.

The Quantity of Milk Required.—An adult in bed with an acute illness, such as typhoid fever, should take about three pints in twenty-four hours. This has always seemed a disproportionately small allowance for the adult, when it is remembered that the healthy child of one year of age is given two and a half pints. Emphasis is given to this disparity when it is remembered that the nutritive needs are proportionate to the amount of fever present.

"We do not appreciate how much a continued high temperature alone exhausts a patient. Were the body composed of water alone, to raise the temperature of a person weighing 150 pounds from 98.5° to 103.5° F., *i.e.*, 5°, to say nothing of the expenditure of force needful to keep it there, requires an expenditure of force equal to raising 285 tons one foot ($150 \times 5 \times 772$ foot pounds). A girl of 100 pounds weight, simply lying still in bed suffering from such a fever, does daily the work of two or three men." * On the other hand, the vast experience of many writers has demonstrated the sufficiency of three pints of milk daily for a fever patient.

The frequency of administration will be determined by the condition of the patient. If eight ounces are given every three hours from 7 A.M. to 7 P.M., and twice during the night, he will receive three pints. If he is given six ounces every two hours, and is fed twice during the night, he will likewise receive three pints. It is good practice to have the milk intended for the patient kept separate from that for household use, so that it may serve as a control record of the quantity administered in the twenty-four hours.

Fortified milk is prepared by the addition of nutritive substances, such as egg albumen, either fresh or dried, or whipped cream.

Milk may be introduced into the dietary in innumerable forms, and with but little change in its character. Served under another name, and slightly different in taste, it is readily accepted by those who decline plain milk. One of the nicest preparations of this class is *plum porridge*, made as follows:

Raisins, minced, twelve; starch (potato or corn), one teaspoonful; milk, one pint. Heat the raisins and milk in a double boiler to the boiling point. Mix the starch with cold water and form a smooth paste; add it to the milk, keep it at the boiling point for five minutes, strain and serve. This preparation has a fruity taste, and is often accepted by an irritable stomach. It is of service in diarrhœa.

Milk may also be administered in the form of pap, junket, whey, koumys, zoolak, matzoon, bonny clabber, curds and whey, cottage cheese, custards, and a great variety of prepared dishes which have milk as their chief constituent.

Koumys is prepared by taking one quart of milk, heated to about 100° F., a tablespoonful of sugar dissolved in a cup of hot water, and a fifth of a yeast cake dissolved in a tablespoonful of cold water. Mix and put in strong bottles—beer or citrate of magnesia bottles are sufficiently strong. Let the bottles stand in a warm place, above the range, for twenty-four hours; then place on their sides in a cool place, *e.g.*, the cellar in summer, or some place where the temperature will be about 60°, for six days. The koumys is then ready for use, and should be drawn off with a champagne tap, because of the likelihood of losing a large portion of it if the cork is removed. The acidity and taste of the preparation will be influenced by the length of time fermentation has continued, and the temperature at which it has occurred. A koumys having a flavor and digestibility suited to the patient may usually be secured by attention to these details.

Milk Jelly.—Heat one quart of milk; then add and stir until dissolved one pound of granulated sugar; allow to boil for ten minutes; then let cool, and when cold add, with constant stirring, one ounce of gelatin dissolved in four ounces of water; when well mixed add the juice of three lemons mixed with a half cupful of sherry wine or good whiskey. Pour into cups, and keep in a cool place. Serve warm or cold.

Junket.—Milk, half a pint; warm to blood heat. Sweeten and flavor to taste. Add the half of a rennet tablet, dissolved in a dessertspoonful of water. Stir. When thickened, place at once upon ice.

Bonny Clabber.—Skimmed milk, preferably in a glass dish, is allowed to thicken spontaneously. This may be fortified by the addition of whipped cream and egg albumen.

Pap.—Flour, one tablespoonful; milk, one pint. Cook ten minutes. The white of an egg may be added.

MEAT.

The use of meat in the dietetic treatment of acute disease is generally confined to the administration of beef, mutton, or chicken, in the form of a fluid representing the soluble constituents of the meat albumen, extractives, salts, etc.

The method pursued in the preparation of these foods will determine their nutritive worth. Thus, beef tea will be a stimulant if the albumen of the preparation is strained from it after it has been coagulated by the application of heat. Beef tea, subjected to a temperature of 212° F., retains in solution only the salts and extractives of the meat, and to these constituents it owes its stimulating property. On the other hand, beef tea is a food if it is prepared in a way to secure the retention of the albuminoid in the finished product.

In selecting the form of beef for a patient, we must be influenced by his digestive capacity. Thus we may give a dilute extract of beef having mildly stimulating properties, or we may select preparations having progressively increasing proportions of nutritive worth, even ordering the entire beef, in which case we should have to consider only the method of cooking it.

The digestibility of the various meats is determined by so many modifying influences, such as the age and condition of the animal supplying the meat, the time that has elapsed since it was killed, the method of preparation, and the digestive power of the individual, that it is not possible to do more than to state approximately the relative digestibility of the various forms of meat.

The order of facility of digestion, other things being equal, is as follows: Oysters, eggs, sweetbread, tripe, calves' brains, white fish, white meat of chicken, beef, mutton, squab, fish, dark meat, game, veal, pork.

The color of meat is influenced by the distribution of the contained fat. The marbling of red meat is due to the fat. The white meat of fowls is very deficient in fat; in this case it is collected in layers and distributed about the white meat. The dark meat is richer in fat, and requires greater digestive power. This fact will influence the selection of fish, fowls, and beef. The fat of mutton has a higher melting point than that of beef and fowls, and for this reason it sometimes occasions indigestion. Cold mutton, in which the fat can be readily separated, will frequently be found acceptable when the recently cooked mutton cannot be digested.

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* W. W. Keen: "Surgical Complications and Sequels of Typhoid Fever," p. 56.

Taking up first the mildest preparation of beef which we are able to offer the patient, we may consider:

Stimulating Beef Tea.—The choice of the cut of beef in making various foods for the patient is of little importance, aside from the question of cost. The meat from the neck will give a preparation quite as nutritious as that made from meat taken from the round steak. Take one pound of beef from the neck, put it twice through the chopper, and place it in a porcelain-lined kettle; add one point of cold water. Allow it to macerate in a cool place for three hours, occasionally stirring with a wooden spoon. Heat the preparation to the boiling point, and allow it to simmer for one hour. Season it to taste. Strain through a double layer of cheese-cloth, cool rapidly, remove the fat, keep securely covered. If it is desired to have a preparation that is perfectly clear, the well-beaten white of an egg may be added, and the tea heated to the boiling point and then strained. This preparation is mildly stimulating and may induce wakefulness in those cases in which a stimulant would produce such an effect, and it is not to be relied upon as a food. Most of the beef tea made from the solid extracts of beef furnishes a product of small nutritive worth.

Beef Extract by the Cold Process.—Minced beef, five ounces; cold water, a pint; hydrochloric acid, five drops; common salt about twenty grains. Macerate in a cool place for three hours, strain through a sieve, and wash the residue with sufficient water to make the finished product measure a pint. Remove the fat, and serve warm or cold.

Nutritive Beef Tea.—Take one pound of beef from the neck, remove the excess of fat, and put it twice through the chopper. Add one pint of cold water, and place in a quart jar. Macerate in a cool place for three hours, with occasional stirring. Make a water-bath, and have the water of the bath extend to the level of the beef and water in the jar. Stand the jar in the water-bath, and heat slowly until the water in the water-bath reaches the boiling point. Lessen the heat and continue its application, not allowing it to reach the boiling point, for a period of three hours. Strain through a sieve, and wash the residue with enough water to make the finished product measure a pint. Season to taste, cool rapidly, and remove the fat. Keep the tea as nearly sterile as possible. Should the patient tire of the flavor of this preparation the taste may be modified by the addition of various aromatics, such as bay leaves, mace, cloves, some minced celery, or aromatic herbs. This preparation if not subjected to too much heat should have a reddish-gray color, and possess nutritive worth.

Bouillon is a dilute form of stimulating beef tea. A shin bone is usually used in its preparation.

Consommé is bouillon flavored with herbs and colored with caramel. The advantages of these two last-named preparations are that we are able to secure them from the hotels and restaurants, and in ordering them for a patient we apparently make a concession to the taste of the individual.

If a stronger beef preparation is desired, we may give beef juice made by taking meat from the neck, cutting it in slices about an inch thick, broiling it slightly in order to start the juices, then cutting the meat into cubes and subjecting it to pressure in a meat press designed for the purpose. The press should be heated before use by pouring boiling water over it, so as not to chill the meat; a warm cup should receive the meat juice, and the meat should be fed into the press in small quantities. In giving the preparation to diphtheria cases salt should not be added, unless it is found necessary to do so, because that contained in the beef is quite sufficient, and any addition of salt would cause smarting of the inflamed mucous membrane. The neck or tender side of the round steak will yield about six ounces of juice to the pound of steak. If beef juice is to be prepared for any length of time, it is more economical to buy a meat press rather than yield to the temptation to temporize with a potato-masher. This is a concentrated form of nourishment, and one well adapted for administration to typhoid-fever patients with perforation or hemorrhage. The residue leaves little to irritate the ulcerated area.

Scraped beef cakes constitute a more concentrated as well as a more digestible form of nourishment than whole beef. They are prepared by taking a steak from the tender side of the round, and, with a knife that is not too sharp, scraping it in the direction of the fibre until the pulp of the meat is removed, leaving the connective tissue. The pulp is then gently pressed into a cake of uniform thickness and is broiled over the coals or in a dry pan. Seasoning and butter should then be added, and the cake put into the oven so that the seasoning may become uniformly blended with the meat pulp. The flavor of this preparation may be changed by adding minced celery, almonds, or pine nuts, and its nutritive worth may be increased by the addition of various nuts, butter, or egg albumen.

Raw Beef Soup may be made by taking the pulp of beef, prepared as above stated, and mixing it with water sufficient to give it the consistence of a cream soup. Salt, pepper, or celery salt may be added, and the preparation may be slightly warmed, if more acceptable to the patient in that condition. This preparation has a field of usefulness in dysentery and certain forms of summer complaint.

Minced Meat Cakes may be prepared by putting a choice cut of beef twice through the chopper and making it into cakes as was directed in the preparation of scraped beef cakes.

If we would give beef in its entirety, it would be best to select the tender side of a sirloin, which will be more tender than any other part, even if it is less juicy. The convalescent is disinclined to make much effort in masticating food, and this necessitates the selection of tender meats, or the preparation of them in a way that will require a minimum amount of effort.

Mutton Broth is prepared by the same method, and the meat is used in the same proportion as directed in the preparation of beef tea. The fat of mutton is less digestible than that of the beef, and care must be exercised to remove every particle of it. An additional reason for getting rid of the small globules of fat is found in the tendency of these particles to float on the surface of the tea and attach themselves to the lips of the patient, leaving a disagreeable after-taste.

Chicken Jelly.—In making chicken broth it is best to select an old fowl. Crack the bones, cover the meat with water, and heat to the boiling point, and continue the application of heat a little below the boiling point for three hours, adding water from time to time to replace that lost by evaporation. Strain through a colander, wash the residue with hot water sufficient to make a pint of fluid for each pound of chicken used, season to the taste, and pour into suitable small moulds. When cool remove the fat with a spoon and damp cloth. Serve cold in the form of cubes, or allow it to retain the shape of the moulds; or it may be warmed and administered as a broth.

Chicken Panada.—Chicken (white meat, raw), one-fourth pound—chop and rub fine; fresh bread crumbs, four ounces; milk, four ounces; whites of two eggs, well beaten. Season and poach in small cups.

Veal Broth.—Veal, chopped fine, one-half pound; cold water, one pint. Macerate for three hours. Water-bath for three hours. Strain, season, cool, and remove fat.

Dietetics of the Sick.

EGGS.

The chemical composition of eggs is as follows:

	White.	Yolk.
Water	84.8	51.5
Albuminates	12.0	15.0
Fats	2.0	30.0
Mineral matter	1.2	1.4
Pigment extractives	....	2.1

The albumen of the white is very easily digested if given raw or so slightly cooked as not to interfere with its digestibility. If well beaten or but slightly cooked, or if it is added to water, it will be found more digestible in some instances than milk.

The large percentage of oil contained in the yolk would indicate its value in those patients who need oil and are able to digest it. It should be slightly cooked. If it is to be given hard boiled, it should be heated until it is mealy and then grated or passed through a sieve.

Eggs may be prepared in many ways. If fresh they are easily digested, and furnish a concentrated form of nourishment.

Eggs should not be subjected to a high temperature in their preparation. A satisfactory method for preparing a soft-boiled egg is to place one egg in a cup containing one-half pint of water heated to the boiling point and allowing it to remain for ten minutes. The cup should not stand on marble or metal, since the cooling of the water would be too rapid for the purpose in view.

A poached egg should be prepared by dropping an egg into water near the boiling point to fix the albumen. It should then be basted with water of a lower temperature, about 170°, until there is a veil over the yolk, and the white of the egg is jellified. An egg prepared in this manner may be given when one poached in the usual way would not be tolerated.

Albumin Water.—The white of one egg well beaten; water, one-half pint. Mix and strain. It may be flavored with sherry or lemon.

Egg Custard.—One egg, beaten; milk, four ounces; sugar, one tablespoonful. Mix and put in cups and bake.

Chocolate Custard is made by adding sufficient chocolate to flavor and color the egg custard.

Caramel Custard is made by adding sufficient browned sugar to impart a caramel flavor to the egg custard.

Brandy-and-Egg Mixture.—Yolks of two eggs; sugar, one heaping tablespoonful; brandy, two ounces; cinnamon water, four ounces. Mix. Administer in tablespoonful doses.

Egg Lemonade.—White of one egg, well beaten; juice of one lemon; sugar sufficient; water, one-half pint. Shake thoroughly. Strain.

Egg Flip.—Milk, hot, one-half pint; yolk of one egg, well beaten; whiskey one ounce. Mix.

Egg Nog.—Put the yolk of one egg with a tablespoonful of whiskey or brandy, a tablespoonful of Jamaica rum, and a tablespoonful of granulated sugar, with a half pint of whole milk into a pint jar, and shake thoroughly until the sugar is dissolved. Beat the white and add most of it to the mixture, and shake again. Put the remainder of the beaten white on the top of the drink, and have the patient take it through a tube or straw.

Bartholow's Food.—Sago, one ounce; milk, one-half pint. Soak for ten minutes, then place in water-bath until clear. To this add: Stimulating beef-tea, one-half pint; yolk of one egg, beaten; celery salt, sufficient. Mix. This is a complete food.

FISH.

The digestibility of fish is influenced by the kind, quantity, and distribution of the oil contained in the meat; and by the season, the freshness, and the method of preparation of the fish.

The blue, dark, and red meats of fishes are due to the presence of oil or fat. In white fish the fat is collected in local parts, and for this reason white fish may be given to those who cannot digest the oil contained in the dark meat.

For the sick, fish should be broiled, and the amount of fat desired should be supplied in the form of melted butter used as a dressing.

If the fish is prepared by being plunged into boiling salted water, and the process of cooking is continued with the water at a slightly lower temperature, it will retain almost all of its nutritive worth.

OYSTERS.

Oysters contain a small proportion of nourishment, and are easily digested if the "eye" is rejected. The juice, prepared by mincing a dozen fat oysters with a silver knife and putting them into a fruit jar and standing the jar in hot water for a half-hour, is often accepted by an irritable stomach that refuses almost all other forms of nourishment.

Oyster Soup should be prepared by taking some flour and butter and mixing them, with the cold milk, gradually added, and then adding the liquor drained from the oysters. This mixture should be boiled for five minutes, and the oysters and seasoning then added; the soup should be served at once. Prepared in this manner the oysters should be plump rather than shrivelled, and the soft parts may be eaten by the patient who is able to digest solid food.

Oyster Broth.—Oysters, twelve; water, two ounces. Mince the oysters. Place over water-bath for a half-hour. Season. Strain.

CLAMS.

Clams have a place in the dietary of the sick chiefly for the juice, which is very acceptable in a great variety of cases.

To prepare clam juice take six large clams, in the shell, scrub the shells, put them into a kettle, add a cup of water, heat until the shells open, pick out the shells and clams with a fork, strain the liquor through a double layer of cheese-cloth, cool rapidly, keep well corked and cool, and dilute with hot or cold water to suit the taste of the patient. Some persons will accept the juice if it is diluted until it has only a suggestion of the clam flavor, who would be unable to take it if it were stronger.

A cream of clams may be made by adding milk and enough flour to give the density desired.

VEGETABLES.

A simple though somewhat inaccurate classification of vegetables is that which divides them into *those growing above ground*, and *those growing below ground.*

ABOVE-GROUND VEGETABLES.—*The green vegetables* possess low nutritive worth. They are difficult to digest because of the large percentage of contained woody fibre, and many are not available for food purposes until they have been cooked. They are valuable for the volatile oils and the large proportion of water they contain.

The cereals approach in character a complete food by reason of the contained gluten, starch, and fat. The proportion of nitrogen is not sufficient, however, for bodily needs without a supplemental supply in other forms of food. The distinguishing advantage possessed by them is that they can be made into bread. Much of the nitrogenous worth of the bread prepared from wheat is sacrificed to the desire for whiteness. The gluten layer of the wheat grain is located directly under the outer bran coat of the grain, and if this were allowed to remain it would give a darker color to the flour and the bread prepared from it. *Whole-wheat bread* contains the gluten and the phosphates of the grain, and for this reason is darker and more nutritious, and because of a small proportion of bran associated with the flour is helpful in overcoming constipation.

Legumes contain nitrogen in the form of proteid, in addition to starch and fat, and are represented by peas, beans, and lentils. They may be termed vegetable meat because of their large percentage of nitrogen, and are more valuable as foods because of the iron and sulphur entering into their composition. It is very difficult to secure all of the nutriment contained in them because of the intimate association of the proteid and starch with the cellulose and the dense capsule substance surrounding them. For those having feeble indigestion they should be thoroughly cooked and passed through a colander to get rid of a large proportion of the associated woody fibre.

BELOW-GROUND VEGETABLES.—*Roots, tubers*, etc., depend upon the contained starch, sugar, salts, and acids for their nutritive worth. Here the food value is lower and less concentrated than in the case of cereals and legumes, and they are poorer in nitrogen. The digestibility will vary according to the age and to the proportion of water lost by evaporation. The starch derived from corn and potatoes, arrowroot and rice, will tax the digestion least. Starches having a cell wall are available as foods only after they have been cooked sufficiently to cause the rupture of the retaining membrane so as to liberate the starch.

FRUITS.

Fruits are valued for their antiscorbutic properties, due to the salts, acids, alkalies, volatile oils, ethers, and the large percentage of water which they contain. They do not possess high nutritive worth.

FUNGI.

Mushrooms are not now regarded as possessing the high food value which was formerly attributed to them. As a seasoning they, with truffles, serve a useful purpose.

BREAD.

Bread for the sick should be thoroughly baked in loaves small enough to insure the destruction of the yeast plant at all parts of the sponge. Freshly baked bread is unsuitable to patients needing dietetic directions. Rasped rolls and thoroughly baked rolls are better than bread cut from the loaf.

Toasted Bread should be prepared from stale bread, slowly heated over the fire until it is cooked throughout its entire thickness, is crisp and has a golden color. The crust should be removed.

Pulled Bread is prepared by taking a loaf of Vienna bread, removing the crust, and separating the sponge of the bread with two forks, or the thumbs, in such a way that the bread is not crushed. Make into strips about four inches long and one inch thick. Place in a pan, the bottom and sides of which have been covered with paper, and bake in the oven until of a golden brown color and thoroughly crisp. It may be served with cream or whipped cream.

Dextrinized Bread is prepared by heating a slice of stale bread in the oven until it is of a dark brown color.

Torrefied Bread is prepared by subjecting bread to a greater heat for a longer period than is used in preparing dextrinized bread.

Brown Flour Soup.—Heat flour in a pan until it has a walnut color. Add a little butter. Form a smooth paste by the addition of hot water, and continue the addition of hot water until sufficient has been added to make the consistence that of a cream soup. Cook for five minutes. Season to taste.

DRINKS AND JELLIES.

There is a class of preparations possessing refrigerant, demulcent, diuretic, diaphoretic, and astringent properties. They have a wide range of usefulness, and the variety of them at our disposal enables us to cater to the taste of the patient.

Flaxseed Tea.—Flaxseed, one tablespoonful, to be washed with cold water; water, one pint. Boil thirty minutes; sweeten; flavor with lemon peel or juice; cool; strain.

Gum-Arabic Water.—Gum arabic, one tablespoonful; sugar, one heaping tablespoonful; water, one pint. Dissolve by means of a water bath. Add lemon juice, one tablespoonful. Strain.

Irish-Moss Tea.—Irish moss, one ounce, to be washed with cold water; water, two pints. Mix and allow to stand for fifteen minutes; heat to boiling point; add lemon juice, two ounces; sugar, two tablespoonfuls. Strain.

Irish-Moss Jelly.—Irish moss, three ounces, to be washed with cold water; water, one pint. Allow to stand fifteen minutes; heat to boiling point and continue at that temperature for five minutes. Strain. Add sherry wine, two ounces: sugar, two tablespoonfuls. Put in moulds to solidify.

Imperial Drink.—Cream of tartar, one teaspoonful; boiling water, one pint; lemon peel and sugar, of each a sufficient quantity. Mix, cool, and strain.

Wine Whey.—Milk heated to boiling point, one-half pint; sherry wine, two ounces. Mix and strain.

Alum Whey.—Milk heated to the boiling point, one-half pint; powdered alum, one teaspoonful, dissolved in water. Mix and strain.

Lemon Whey.—Milk heated to the boiling point, one-half pint; lemon juice, two teaspoonfuls. Mix and strain.

Rice Water.—Rice, one tablespoonful, to be washed. Then add boiling water, one pint, and boil for half an hour. Add lemon peel sufficient; cool. Strain.

Toast Water.—Toast thoroughly a slice of bread. Pour over it six ounces of boiling water. Cover. Allow to stand in a warm place for fifteen minutes. Administer by the teaspoonful.

Corn Water.—Brown a tablespoonful of corn meal in a pan; add six ounces of hot water; boil for five minutes. Strain.

Barley Water.—Pearl barley, two ounces, to be washed; water, four pints. Mix and boil to two pints. Flavor, sweeten, and strain.

Barley Water with Patent Barley.—Patent barley, two tablespoonfuls; cold water, two tablespoonfuls; salt, sufficient; sugar, one tablespoonful; boiling water, one pint. Mix and boil for five minutes.

DIETETICS FOR PARTICULAR DISEASES.

Stomatitis.—Hot water taken freely an hour before meals is of great service. If bicarbonate of soda is added to the water the effect will be better. A milk diet with pulled bread or dextrinized bread is best. White meat may be allowed in small amounts. Acids and fats are to be avoided, as are foods likely to undergo fermentation.

Tonsillitis and Pharyngitis.—There is usually associated with these diseases a mild febrile process, and the same diet is suitable to both conditions.

Diluent and demulcent drinks, such as rice water, barley water, or oatmeal water, are nutritive and serviceable. Irish-moss tea or jelly, flaxseed tea, gum-arabic water are soothing, and imperial drink is refrigerant.

The proper diet should be one containing a large quantity of water. Whole or skimmed milk, or milk with barley or rice water, is to form the chief article of diet. Alum whey is of great service because of its nutritive worth, and because it enables us to vary the diet. Junket, milk-jelly, water ice, and ice cream are allowable. Gruels and creams of various vegetables may be given. Animal broths should be omitted, except those prepared from oysters and clams. The subject will be fully considered in the section devoted to the Dietetics of Diphtheria.

Stenosis of the Œsophagus or of the Cardiac End of the Stomach.—The character of the cause of the stenosis will influence the selection of the diet, as will likewise the degree of obstruction. Milk, plain and modified, is to be considered the standard diet. A complete food is to be constructed from milk, eggs, and cereal. We have an example of such in "Bartholow's food." Scraped beef and finely minced chicken can be combined with milk and, in case of deficient digestive power, these combinations may be peptonized. The semi-solid foods, such as wine jelly, calf's-foot jelly, gelatin preparations, Bromangelon, junket, and ice cream are easily swallowed.

Acute Gastritis.—The temporary avoidance of food administered by the mouth is frequently the prime indication. If the strength of the patient is exhausted, it may be necessary to resort to rectal alimentation. Cracked ice may exert a quieting influence upon the gastric irritability. Hot water is of the greatest service even when it is not retained. More acceptable and likely not only to be retained but also to allay vomiting, is clam juice. For the earlier stages there is nothing better than this preparation. The method of administering it and all nourishment in this condition is quite as important as the selection of the particular kind of food. A teaspoonful of liquid food given every five or ten minutes, or every minute, until four or eight have been given, is much more likely to be retained than are larger quantities. After the irritability of the stomach has once been allayed and digestion begins to be performed, the interval between feedings and the quantity and variety of food may be increased. Milk with carbonated water, whey, junket that has been passed through a colander or sieve, albumin water, koumyss, or zoolak may be given. Toast water or corn water and dry toast will often allay vomiting. Oyster juice fed very slowly is serviceable in these cases; later, scraped beef and chicken panada, or the white of a poached egg with pulled bread, will be acceptable.

Chronic Gastritis.—The condition with which the gastritis is associated will influence the choice of diet. The liberal use of hot water, or hot water with bicarbonate of soda and essence of peppermint, will facilitate the removal of the tenacious mucus so constantly present in these cases, and give a better opportunity for the gastric secretion to act.

The condition is so constantly associated with obstruction of the portal circulation that no food must be given that would tax the hepatic function. For this reason buttermilk, which represents sweet milk with a large part of the fat removed, is regarded by many as the ideal diet for these cases. Skimmed milk is serviceable for the same reason. Milk, diluted with hot water, with carbonated water, or with a water prepared from one of the cereals, to render the curd smaller, is to be regarded as especially indicated.

It is a safe general rule in dietetics to give that food which will tax the affected organ least—in other words, to rest the disabled viscus. This rule would indicate the use of fats and starches in gastritis. Fats are contraindicated, however, for the reason given. Starches are of service in many of these cases, but their use must be watched because of the liability to occasion the development of water brash, or heartburn, due to lactic or butyric acid fermentation. Corn starch, arrowroot, and white potatoes should furnish a starch most easily digested. It need hardly be added that care and skill in the cooking of these cereals will greatly influence their digestibility.

The stimulating beef-tea in the earlier stage, and the nutritive beef-tea when the condition improves, will be found serviceable. Scraped beef, or beef reduced to a pulp by means of a mortar, and the fibres drained from it, will be easily digested. The judicious use of condiments in these cases will be of service in stimulating the gastric secretions.

One thought is to be kept constantly in mind in the treatment of these cases—that is, that no food shall be given that is liable speedily to undergo fermentative changes, or to remain long in the stomach. For this reason, spare, cold boiled ham, and other smoked meats are often more acceptable than other forms of nourishment.

In those cases in which the disease is associated with deficient motor power, the interval between feedings should be lengthened, and an effort made to cleanse the stomach of the remnant of the previous meal before more food is introduced.

Eggs are more available if the whites only are used. They should be poached at a low temperature, or well beaten, and should be combined with other forms of nourishment. Oven-baked toast, or pulled bread, will be the form of bread least likely to induce flatulency.

Dyspepsia.—The term is applied to a group of symptoms including those previously considered under acute and chronic gastritis. In addition to these two classes of gastric diseases there are cases with symptoms so pronounced as to enable them to be considered under the following heads: Atonic dyspepsia; nervous dyspepsia, including gastralgia; intestinal dyspepsia.

Atonic Dyspepsia.—Hot water should be given immediately upon rising to cleanse the stomach of accumulated mucus, and a glassful of cold water before meals for its tonic effect. See to it that there are teeth to perform the work of preparing the food for digestion. It is more promising to treat certain dyspeptics by ordering teeth than by the employment of countless drugs and diets. When the teeth are unsuited to grind and cut the food, it must be artificially done or the diet will have to be confined to the foods requiring no mastication. Each meal should consist of one or two articles of diet. Beef combined with rice will give a complete food because there is sufficient fat inseparably associated with the beef to yield as much of this food element as is likely to be digested with facility.

Fruits are of service in this case, especially if taken before the meal. Those containing a minimum of acid, such as oranges, bananas, and grapes, if taken before breakfast will frequently stimulate digestion. Certain cases will be met with in which the fruits are better borne if taken at the close of the meal. This is particularly true of the more acid fruits, such as strawberries.

For breakfast a broiled chop, the white of a poached egg, a cereal, if thoroughly insalivated and if not too much sugar is used, combined with toasted or whole-wheat bread, or shredded wheat, would make a suitable meal. Cambric tea is to be preferred to tea or coffee. For dinner, a cup of hot stimulating beef-tea, consommé, or bouillon will stimulate digestion. This may be followed by a meat cake, prepared by passing beef twice through the chopper or by scraping it. A mealy baked potato is allowable, and this may be made more digestible by having the potato removed from the skin after baking, incorporating with it butter and seasoning and, in certain instances, the white of an egg, replacing the mass in the potato case and heating so that the seasoning may be thoroughly blended and the starch granules separated. Steamed rice, macaroni, vermicelli, or any of the Italian pastes may be given, and when combined with grated Parmesan or American cheese will constitute a complete food. If the diet is confined to one or two articles of food we are able readily to determine the influence of the food elements administered upon the course of the disease. This point is not sufficiently appreciated, and its neglect often results in failure in the dietetic treatment of disease. When there is hyperacidity, scraped beef as an exclusive diet will often give the best results. In those cases in which there is hyperacidity the starches, if thoroughly insalivated, are apt to be more easily digested.

Water with the meals is of advantage because of its solvent effect and its mechanical aid in separating the particles of food and thus facilitating the action of the gastric juice upon the aliment. Constipation is a less prominent symptom when sufficient water is taken. Too much water, on the other hand, may retard digestion by excessively diluting the digestive ferments.

Nervous Dyspepsia.—In these cases the disease manifests itself by symptoms referable to the nervous system and associated with these there are variable appetite, clean tongue, and a pain in the region of the stomach, which latter is often relieved by taking food. The element of pain may be so pronounced as to justify considering the case one of gastralgia. According to the degree of severity of the symptoms will be the necessity for a rigid dietetic regimen. Rest before and after food is most helpful. The meals should be taken under a cheerful environment. Anything tending to depress, irritate, or call attention to the patient's invalidism is to be avoided. An exclusive milk diet may be necessary. Later, fruits, eggs slightly cooked, bacon crisp and dry, with dextrinized bread, should compose the breakfast. Coffee is to be avoided, and tea also, unless it be weak and freshly brewed, and taken several hours after the meal.

Intestinal Dyspepsia.—It is not difficult to appreciate that the most probable exciting cause of this condition is to be found in the excessive use of improperly cooked starches. Potatoes yielding themselves to many improper methods of cooking are doubtless potent factors in the production of intestinal dyspepsia. Here the starch is made difficult of digestion by reason of the frying to which they are often subjected, and the fat used in the process has been heated to a point where its chemical composition is changed, when it becomes unsuited for food purposes as is starch which has been cooked in it.

The breads usually found on the table are frequently of such composition or in such a condition as to make them a tax upon digestion. Among the poorer classes the meal is often largely made up of bread and a liberal allowance of tea and sugar. There is another class of foodstuffs that have contributed largely to the causation of this disease, the cereals; the coarse oat-meals that have been cooked for as brief a period as a half-hour are better adapted for bill-posters' buckets than for human stomachs. The treatment of the condition after the elimination of the exciting cause resolves itself into the administration of the foods that are digested chiefly in the stomach. Hot water, skimmed milk, milk in all possible combinations, and milk with the curd made small, will be found serviceable in all of these cases.

Clear soup made from meat, and scraped or chopped meat cakes with dextrinized bread, will stand for the diet best adapted to these cases. These articles of diet are quite sufficient for a considerable period of time if prepared in the various combinations to which they lend themselves. Later, slightly cooked egg albumen may be added to the diet, and as the condition improves, sweetbreads, calves' brains, squabs, white meat of chicken, bacon, and game. The starchy foods are to be added gradually and the effect watched. Macaroni, vermicelli and noodles, steamed rice and corn starch, and later a baked potato may be added to the diet.

Tea and coffee, as they are usually prepared and used, are objectionable in all forms of dyspepsia. Coffee if diluted with hot milk is less likely to tax the digestion than is tea. The question of stimulants and wine is a less pressing one here than abroad. For the debilitated or aged, champagne, or brandy diluted with carbonated water, when taken during the meal, will frequently prove of the greatest service.

Ulcer of the Stomach.—The rule to spare the affected part applies with special force to this condition. The ulcerated gastric mucous membrane must not be irritated by coarse food, excessive food, or a free flow of gastric juice, because the likelihood of hemorrhage is increased by coarse particles of food, and by distention of the stomach by food or gas. Carbonated water is not to be used in diluting the milk that is so large a part of the diet, unless the mixture is allowed to stand until effervescence has entirely ceased. Milk, prepared in this way, will form a flocculent curd. When hemorrhage has occurred, it is advisable to give little or no nourishment by the mouth, and to use instead nutrient enemata.

From observations that milk is capable of absorption directly without undergoing coagulation and digestion, provided it is given when there is no other food in the stomach, it would seem that we should in a great measure limit the dietary of these cases to the administration of milk.

Since the administration of an alkali stimulates the flow of the acid gastric juice, it would manifestly be wise to use the alkali with caution, and in such quantities and at such times that the acidity of the gastric juice may be neutralized. For these reasons partly, rice, or albumin water, will be more serviceable as an addition to the milk. Curds and whey, if passed through a sieve, may be used.

As convalescence becomes established, the patient may have cream soups of the various vegetables, always observing the precaution that they be strained through the colander or sieve. Meat soup, free from fat, scraped meat cakes, or minced white meat of chicken, cream sweetbreads, and strained gruels, or combinations of these food elements, may be employed in these cases.

The dietetic treatment of a case of gastric ulcer should extend over a period of from four to six months.

Cancer of the Stomach.—If the lesion is situated at the cardiac orifice and is sufficient to prevent the ready entrance of food into the stomach, it will become necessary to use the stomach tube in feeding the patient. If the pyloric orifice is the seat of disease, the likelihood of gastric dilatation and its attendant catarrh is proportionate to the degree of stenosis. The food in either instance should be either liquid or semi-solid. Milk combined with eggs, beef, or one of the starchy vegetables will offer a sufficient range of nourishment. The white of egg may be given with milk or broth. The yolk can be administered with less objection in these cases, especially if it is associated with pancreatin and soda.

Scraped beef, beef peptonoids, and strained gruels are to be given.

An early, careful employment of rectal feeding will prove a valuable supplemental source of nourishment. Later, it will likely be the only means of sustaining the patient.

Pyloric Obstruction and Dilatation of the Stomach.—The diet suitable for chronic gastric catarrh and cancer of the stomach, with certain slight modifications, will be found adapted to these conditions.

Constipation.—One of the most important directions that can be given a patient with this troublesome complaint is that a hard-and-fast rule be observed in the matter of having a fixed hour each day, at which an effort to have a bowel movement will be made. A glass or two of hot water, sipped at intervals during the progress of the toilet, and if necessary, the same quantity of water taken before retiring, will greatly favor a daily evacuation of the bowels.

The condition is constantly associated with a deficiency of the liquid element in the intestinal contents. Either there is a deficiency of water ingested, or that taken is lost by excessive perspiration, and the fecal matter in this way becomes inspissated, and constipation results.

Fruits, either raw or cooked, and dried fruits according to the digestive power of the individual, are of the greatest service in overcoming constipation. They act more by virtue of the acids and the water contained in them than by their bulk and mechanical irritation of the intestinal tract.

Most of the dried fruits are more easily digested if cooked. *Prunes* should be deprived of the skin, and thorough mastication of the fruits having much woody fibre should be insisted upon.

Vegetables, especially the green vegetables, *e.g.*, spinach, lettuce, peas, beans, celery, and others, by reason of the water and acids they contain and the residue they leave, contribute to overcome constipation.

When it is remembered that approximately more than three-fourths of most vegetables are composed of water, it will be more readily appreciated how these foods exert an apparent effect by liquefying the intestinal contents.

When the constipated habit of the meat-fed dog is contrasted with the semi-solid character of the evacuation of the herbivorous animals we have an important dietetic suggestion.

Cereals are helpful in the treatment of these cases, if they are prepared in such a way as to leave the bran layer of the grain in the meal.

In this way we secure, by bulk and mechanical irritation, a stimulus to peristalsis. Bran bread, ginger bread, graham bread, brown bread, the various cereals comprising the breakfast foods on the market, and the gluten, ginger, and smaller biscuits of the shops may be used in this condition.

Milk is less constipating if it has not been skimmed, the fat of the cream being laxative. One of the best aperients for babies is cream.

Bacon cooked until crisp and dry is serviceable, by reason of the fat of which it is composed.

Butter, in large quantities upon gluten, bran, or brown bread, will be of service. Oils, with green vegetables, may be used.

When the condition is the result of dyspepsia, it is important to avoid making any pronounced change in the diet without giving a due consideration to the digestibility of the food selected; as woody vegetables, so serviceable in constipation, are very difficult of digestion.

Acute Diarrhœa.—Acute diarrhœa is to be treated according to the cause which occasioned it. If an irritating substance has been ingested or developed, the withholding of all food for a time after the irritant has been expelled will prove the best initial treatment.

Albumin water is serviceable. Boiled milk, skimmed milk, or milk to which flour has been added and boiled (making the preparation known as "pap"), will prove acceptable. Brown-flour soup, "gebrannte Mehlsuppe" of the Germans, with or without ginger or other acceptable spice, is highly regarded, while beef scraped or the pulp prepared by pounding the beef in a mortar with water or milk and then strained, is to be given. The latter preparation may be peptonized.

Chronic Diarrhœa.—The condition with which the diarrhœa is associated will influence the dietetic treatment. The food should be administered in small quantities and at frequent intervals. Fermentable foods, and those likely to excite diarrhœa, are to be avoided. Chicken and game meats are to be considered in this class. It is important that the intestines shall be spared every effort, as far as possible, to digest and assimilate the food administered. This means that egg albumen, skimmed milk, buttermilk, sterile beef-tea, beef juice, and scraped meat should form the chief constituents of the diet. Koumys, zoolak, cottage cheese, and certain of the manufactured foods are also available. If judiciously administered, these articles will prove an acceptable diet for a protracted period.

When the digestive power increases dextrinized bread, or flour soup, cream of potatoes, corn starch, and "pap" may be given. Farina gruels combined with whites of eggs are suitable to these cases. Brandy and red astringent wines, such as Burgundy or claret, will be serviceable in certain cases.

Dysentery.—The acute and chronic forms require those foods which are digested and taken up by the stomach and leave a minimum residue.

Egg albumen, sterile beef-tea, beef juice, scraped beef, gelatin foods, skimmed milk, and milk fortified by the addition of albumen, curds and whey, grated cheese, koumys, and similar foods are to be considered the chief articles of diet. The return to a diet containing starch, sugar, and fats should be long deferred and cautious.

Intestinal Diseases of Childhood.—It is possible to consider a large group of separate conditions under this heading. In all of them the limit of bacterial invasion consistent with health has been passed. In the successful treatment of these cases the first requisite is to secure the closest possible approach to sterility of the gastro-intestinal tract and to introduce no food that will carry re-infection or yield a favorable medium for the development of pernicious forms of bacterial life. These diseases are usually associated with an inability to readily digest the casein constituent of milk, and this inability manifests itself by the occurrence of colic soon after taking food and by the presence of curds of varying sizes in the evacuation. The casein should be lessened by the dilution of the milk with water or other diluent. In those cases in which there is a total inability to digest casein, whey will be found acceptable. Albumin water is in favor in these conditions. Partial peptonizing may enable the patient to digest ordinary milk. The simple dilution of the milk lessens the proportion of sugar, and thus the likelihood of fermentative changes and acid stools is lessened.

The fat of the milk is likely to favor diarrhœa and vomiting. Skimmed or boiled milk will be indicated in those cases in which there is reason to believe that the patient is unable to digest the fat. The advantage of a temporary withholding of food is not to be forgotten. Beef juice diluted with warm water, mutton broth, veal broth, or barley and egg water, will each be found serviceable. There is no dietetic regimen, just as there is no particular food that is adapted to every one of these cases. The food must be modified to meet what we conceive to be the existing condition and the digestive power of the parts involved.

Acute Appendicitis.—An acute attack of appendicitis demands a liquid diet. There should be no excessive residue; neither should there be so little residue as to favor the occurrence of constipation with the attendant likelihood of extension of the inflammatory process. Thus milk, toasted bread, freshly prepared broths, egg albumen, and gelatin preparations would yield a suitable dietary.

Chronic Appendicitis.—Foods which would yield a coarse bulky residue, and improperly cooked meats are to be avoided. Oatmeal as ordinarily prepared by being boiled for as short a time as half an hour is not suitable for food purposes. Cabbage, corn, and fruits containing seeds or having dense skins are to be omitted because of the tendency to induce intestinal indigestion and flatulency, and not because of the danger of their entering the appendix. Thus the class of articles to be avoided constitutes the chief dietetic direction to be given to these patients. Over-eating, gamey food, the ingestion of a large quantity of very cold food, ice cream, or beer, may aggravate the disease. The diet should be a simple mixed one, containing no elements likely to tax digestion or to favor the development of intestinal catarrh. Thus, the legumes represented by peas, beans, and lentils with dense skins, and sulphur as a constituent, are objectionable. Corn is more likely to do harm in these cases than is cornlet or the cornmeal. Pickles, onions, and highly seasoned condiments are of questionable utility.

Jaundice, Biliary Calculi, and Cirrhosis of the Liver.—In the dietetic treatment of these conditions sugar is to be eliminated as far as possible from the food. Starches are to be reduced to a minimum because of their change into sugar in the course of the process of digestion. So far as possible it is well to administer starches only in moderation and those combined with gluten, *e.g.*, macaroni, vermicelli, and rolled wheat. Rice, tapioca, sago, and arrowroot may be given. Potatoes are permissible if given in moderation, but the vegetables poor in starch are to be preferred. Cream soups, spinach, celery, lentils, peas, and beans are of value in these cases. Fruits of the subacid variety are permissible, as apples and oranges.

Milk is allowable, but should be thoroughly skimmed to exclude the fat, and diluted to reduce the curd. Some objection has been made to the use of milk because of its sugar. The sugar of milk is less objectionable, however, than the cane sugar and need not to be so rigidly excluded from the diet. The use of butter is to be curtailed or entirely omitted. The white of egg prepared in various ways will furnish the albuminoids required for food purposes; but the yolk is objectionable.

Fish, particularly the white fish, may be given; the oily varieties represented by mackerel, eels, and herring are to be avoided. Meat in the morning is permissible, it always being remembered that red meat is to be sparingly used unless the patient is expending energy.

If wines are demanded the sweet ones should be avoided, and extra dry champagne or Moselle wine should be selected.

Acute Nephritis.—The ideal food is milk. In truth it seems to be the only food suitable to the condition, and it becomes a question of the method of administration of milk rather than of the selection of a dietary (see section on Milk).

For the sake of variety, when the patient rebels against a milk diet, some one of the waters prepared from the cereals may be given. The carbonated waters are serviceable in these cases. A departure from the exclusive milk diet should be regulated by the condition of the urine. The starchy foods are to be added to the diet gradually, and if no untoward effect is produced, the lighter meats may be cautiously added.

Chronic Parenchymatous Nephritis.—One of the greatest dangers for these patients is the appetite. The protracted privation of ordinary foods seems to make the appetite more voracious. The close causal relationship between the ingestion of meat and the development of uræmic convulsions is fully established. "The good results of the milk treatment in cases of chronic nephritis is now among the best acknowledged in the treatment of the malady, as evidenced in the diminution of albumen, decline in dropsy, increase in the quantity of urine passed, and general amelioration of symptoms." (Tyson's "Practice of Medicine," pp. 6, 99.) These patients should take from five to nine pints of milk in the twenty-four hours, according to the amount of energy expended. When the fullest measure of benefit obtainable from an exclusive milk diet has been attained the quantity administered may be lessened and starches cautiously introduced to compensate for the deficiency of this constituent absent from the milk diet.

Chronic Interstitial Nephritis.—Here, as in other forms of nephritis, a milk diet is the one that yields the most satisfactory results. Fortunately, the range of combinations with other foods is not so limited as in the cases previously considered. To maintain a condition of metabolic equilibrium is of prime importance, even if there should result a moderate increase in the percentage of albumin in the urine. Since meats are so closely associated with the development of complications in these cases, it is to be remembered that a uric-acid-free diet can be obtained by securing the nitrogenous constituent necessary for a complete food from milk and cheese. Haig* points out that a man weighing one hundred and forty pounds will require 1,470 gm. of albumin a day, and this may be obtained from any one of the tables herewith submitted:

TABLE I.

					Grains.
Ten ounces of bread......	8	per cent.	of albumins	=	340
Two ounces of oatmeal...	12	"	"	=	104
Two pints of milk.........	3	"	"	=	525
Two ounces of cheese.....	33	"	"	=	281
One ounce of nuts	16	"	"	=	68
Eighteen ounces of fruit and vegetables, say.....	0.5–2	"	"	=	152
					1,470

TABLE II.†

					Grains.
Five ounces of bread.........	16	per cent.	of albumins	=	340
Two ounces of oatmeal......	12	"	"	=	104
One ounce of gluten.........	80	"	"	=	344
One pint of milk	3	"	"	=	262
Three ounces of cheese......	33	"	"	=	421
					1,471

TABLE III.

					Grains.
Three ounces of cheese	33	per cent.	of albumins	=	421
Three pints of milk	3	"	"	=	787
Fourteen ounces of potatoes.	2	"	"	=	120
Sixteen ounces of fruit......	2	"	"	=	137
					1,465

The possibilities of a meat-free diet are great and promise most in these cases. The advantage of having the diet composed of few articles in the proper proportion is well illustrated in these cases, in which it is necessary to note the effect produced by various food combinations.

Uræmia.—The diet suitable to a case of acute nephritis, as indicated above, will be found to be best adapted to cases of uræmia. Skimmed milk is the form best adapted to these cases.

Circulatory Diseases.—The success of all dietetic measures is dependent upon the integrity of the circulatory mechanism. The activity of the digestive juices is determined by the character of the circulatory fluids of the body; the functions of all of the organs of the body are influenced by the character and the quantity of the blood they receive; the metabolism, absorption, and nutrition of all of the tissues are proportionate to the completeness with which the heart, the vessels, and the blood perform their physiological functions. It is the intimate interdependence of the various functions that explains the constant association of certain symptoms, *e.g.*, the dyspepsia, indigestion, palpitation, and constipation, which are associated with anæmia. It is in this manner that morbid states are perpetuated. Dropsy results from watery blood, transudation of the liquid element of the blood being favored by a condition of hydræmia; and this condition is the result of deficient nutritive elements. It is not possible to continue for a protracted period a dietary unsuited to the kind of work being performed.

Anæmia.—The form of this disease most frequently met is that associated with the period of puberty in girls. At this time growth and development are more active than previously. The nervous system is actively concerned in this transitional state and doubtless exercises a determining influence in the early manifestation of digestive involvement. The intake of food after the condition is established is unsuited in character and quantity for the constructive needs of the system at this time. The excessive consumption of the nitrogenous elements is evidenced in the increased quantity of urea eliminated. The inclination of the patient is to sweets and starches, if an actual perversion of taste does not exist. In all cases in which there is a departure from the normal composition of the blood the same dietetic rules will be found serviceable. The condition essential to a normal blood supply is that sufficient food be taken, digested, and assimilated. With food as with the administration of iron in this condition, the question is not so much how great an amount may be taken as how best to secure the assimilation of the largest possible quantities. A diet deficient in albuminoids has been found constantly associated with a hydræmic condition of the blood. It would therefore seem to be of prime importance to prescribe in these cases a diet containing the largest possible quantity of albuminoid food. In the severer forms it will be necessary to peptonize the food and to give small quantities at frequent intervals. Milk and meat are the foods most suited to meet the requirements, and they are the forms of nourishment likely to be most distasteful to the patient. It therefore becomes a question of presenting them in the forms least objectionable. Scraped meat cakes, meat powder and broths, pounded meat, bone-marrow soup or sandwiches, or sandwiches of gluten or whole-wheat bread with dry crisp bacon, lettuce and mayonnaise dressing, chopped meat with celery, or pine nuts or almonds, offer attractive combinations for the administration of meat. Cheese combined with Italian pastes, macaroni, vermicelli, or noodles, or with potatoes, yield the desired nitrogenous element. Fats seem to be especially helpful in curing this condition, and by the liberal use of cream prepared in an acceptable way, or of butter and whole-wheat bread, or by the administration of small doses of cod-liver oil, we are able to secure fats in an assimilable form. Creams of the nitrogen and iron containing vegetables are not to be neglected. It is held by some that the iron in combination with vegetables is the most assimilable form. Thus we should use carrots, beets, spinach, peas, beans, lentils, and gluten meals.

Laryngitis, Tracheitis, and Bronchitis.—The diet adapted to any acute febrile process will be suitable to these conditions, and will be discussed under that heading.

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* Haig: "Diet and Food in Relation to Strength and Power of Endurance," 2d edition.

† While most of the percentages of albumins in these two tables are from Parkes' "Practical Hygiene," 5th edition, with which my researches agree, the value of "Hovis" and of nuts is that calculated from my researches alone.

Asthma.—The importance of dietetic measures cannot be overestimated in the treatment of this condition. The proper preparation of the food and of the stomach for its reception, combined with the adjustment of the food to the work being performed, will give results justifying the care exercised.

Hot water should be given an hour before meals, and at bedtime. In certain instances the addition of bicarbonate of soda and essence of peppermint will give good results.

Breakfast should be composed of eggs with dextrinized bread, creamed chipped beef, fresh or smoked fish; a cereal with a liberal supply of milk, *e.g.*, a pint, and little or no sugar, may prove an acceptable meal.

Dinner, which should be taken at noon, may consist of a clear soup, or cream of potatoes or similar nutritious vegetable; macaroni and cheese, or some form of meat, furnishing the nitrogenous element. The starchy food should be confined to one vegetable, and it may be steamed rice, a small potato, or spinach after it has been passed through the colander. Junket, corn starch, or apple tapioca may be eaten as dessert.

For supper milk, milk jelly, Bartholow's food, or a cereal will be suitable. If the patient is expending considerable energy, some cold boiled ham, tongue, or sardines may be allowed.

Beverages.—It is best to withhold the use of tea and coffee and reserve the therapeutic effect of these beverages for the favorable influence they exercise on the paroxysm. Water is not to be taken with meals except in the smallest quantities.

Fatty, fermentable, bulky foods are to be avoided. Should the case present an excess of uric acid in the urine, the diet should be confined to "uric-acid-free" substances. The diet composed of "uric-acid-free" substances is worth an extended trial. In so many instances the paroxysms occur on Sunday night, that one is forced to recognize the probability of the increased intake of food and the diminished expenditure of force on that day as bearing a causal relationship to the development of these attacks. These patients may take the following foods: White meat of fish and chicken, beef soup, scraped, pounded, or chopped beef, eggs slightly cooked, green vegetables free from oxalates, coffee, and water in moderation. The carbohydrates should be confined to one variety with any one meal, and this one should be a form of easily digested starch.

Asthmatic patients should avoid coarse fermentable foods—indeed, an excess of any kind of food; fats should be avoided, or taken in the form of butter. Malt liquors should not be taken.

Pneumonia.—In this disease the only necessary modification of the diet suited to an acute fever is the curtailing of the considerable quantity of fat likely to be present in the cream associated with the milk which constitutes such a diet. When it is remembered that fats are carried directly to the lungs, where their oxidation occurs, it will be appreciated that they should be withheld, and the acutely inflamed lungs spared the effort incident to the combustion of fat.

In the puny youth, or decrepit old patient, the nutritive worth of the milk may have to be increased by combining with it strained gruels of arrowroot, barley, oatmeal, or corn starch.

Pleurisy with Effusion.—"A dry diet" suggests the object sought in the effort to influence this condition by means of food. The amount of fever present will determine the extent to which the exclusion of liquids may be pushed. A diet made up largely of scraped beef, minced chicken, cereal foods, cheese, macaroni, vermicelli, curds and toasted bread, will most favor the absorption of the exudate, and should be employed if not contraindicated by other conditions present. Vegetables containing a large percentage of water, such as potatoes, beets, tomatoes, etc., are objectionable.

Pulmonary Tuberculosis.—The diet should be adapted respectively to each one of the three periods of the disease.

In the first stage any combination of foods that will bring the patient to a higher nutritive level, giving most fat and a corresponding improvement in the blood with a minimum expenditure of energy in digesting the food, is best suited to the condition.

Forced feeding—made possible by the use of bitter tonics or the employment of a stomach tube—is to be employed so long as it does not excite gastric catarrh. Fats are of prime importance, and may be given in various forms: for example, butter, thickly spread upon gluten or whole-wheat bread or biscuit, or upon meats and in every possible form; cream in as large quantities as can be digested; fat of roasted or of broiled meats; and meats containing large quantities of fat, *e.g.*, game and squabs. It is reasonable to attribute a part of the value of fats in these cases to the exercise given the lungs, although their primary function as nutriment should not be lost sight of.

Milk, if sound, is second to no other food in these cases. It should be given in every possible form—whole, skimmed, buttermilk, koumys, matzoon, zoolak, cottage cheese, cream cheese, junket, bonny clabber, puddings, and in every possible combination that may prove palatable.

Red and dark meats are preferred because the fat is contained between the fibres, and is more accessible than when it forms a separate layer, as in the case of white meats. Roasts, steaks, chops, beef chopped, scraped, or pounded, beef juice or nutritive beef-tea, beef with minced celery, or with pine nuts, onions or other seasoning to stimulate digestion and aid nutrition, are of the utmost value.

Eggs in any one of the five hundred ways in which they may be prepared are of especial value. The large percentage of oil contained in the yolk, and the easy digestibility of the albumen, make them an important food. The dried white of egg may be added to broths and soups, and in this way a large number of eggs may be consumed in a day.

The cereals and more easily digested forms of starch are best suited to furnish the carbohydrate element of the food. Fermentable foods, as hot bread, starches, and pastry are to be avoided. Malt extracts are serviceable as aids to digestion. There are numerous "diet cures" for tuberculosis and, as in most instances, the multiplicity proves the inefficiency of any one system.

In the second stage of the disease the same dietary will be suitable, if care is taken to restrict the food requiring the most active digestive processes to the periods when the patient has the least fever. Regard must also be paid to the catarrhal condition of the digestive tract, so often present in these cases.

In the third stage of tuberculosis the food must be confined to the articles that yield most nutrition and tax the digestion least. There are numerous instances in which patients with advanced tuberculosis eat excessive quantities of the foods least adapted to their condition with apparent impunity. There is no food that will do more to prolong the life of these cases than egg albumen in large quantities. It seems to act as pine shavings to a nearly extinct fire. The objection that holds against the administration of alcoholic beverages in the earlier stages of the disease does not apply to patients at this period. Whiskey and brandy, judiciously administered, are of positive value.

Acute Infectious Diseases.—Groves secured immortality by the request that "I fed fevers" should be his epitaph. The careful adjustment of food to the febrile condition would be a better reason for grateful remembrance. There can be no doubt but that much harm may be done by allowing a too extensive dietary to fever patients. It is only by keeping in mind certain well-established conditions that we are enabled properly to appreciate the dietetic indications.

1. *In fever there is excessive destruction of the fluids and tissues of the body.*

(*a*) The loss of albuminoid is greatest. It is indicated in the increased excretion of urea, and is measured by the muscular wasting and debility.

(*b*) The destruction of fat is evidenced by the emaciation and the increased excretion of CO_2.

(*c*) There are marked changes in the composition and quantity of the liquid elements of the body.

2. *The digestive and assimilative processes are perverted.*

(*a*) Gastric digestion, which is chiefly concerned in the utilization of albuminous, and to a minor degree of the fatty foods, is usually the function most seriously involved.

(*b*) Intestinal digestion is less perverted, and the carbohydrates and fats are more available for food purposes, provided they are given in liquid form.

There is, therefore, need to adjust the dietary with reference to the affected part, and—according to our estimate of the ability of these respective parts to perform their functions—to give foods which require either chiefly a gastric digestion or chiefly an intestinal digestion.

The excessive destruction of albuminous tissue, with the attendant increase in the urea to be eliminated, should make us watchful that there is no failure to excrete these products of nitrogenous waste.

3. *Adjustment of food to the existing conditions.*

(*a*) The food should be fluid; solid food frequently excites nausea and vomiting.

(*b*) It should be sufficient to equalize a part of the combustion coincident with the fever. This may be accomplished by supplying:

(*α*) Albuminous food in the form of milk, meat broth, or egg albumen.

(*β*) Carbohydrate in the form of strained gruel, toast, barley water, or some similar diluent and nutritive liquid.

(*γ*) Fat must not be given in greater quantities than is present in the cream of whole milk.

There are two conditions constantly present in febrile processes: first, increased combustion, and second, diminished assimilation.

When the excessive quantity of food required to furnish heat for one degree of bodily temperature is taken into consideration, it is manifest that we cannot hope to give sufficient food to compensate for the destruction of tissue resulting from the febrile process. Our aim should therefore be to give nourishment in a form that will tax least the enfeebled digestive organs, and that may be most readily assimilated.

The digestive juices are scantiest when the fever is highest, therefore adjust the administration of the most nutritive food to the time when the temperature is nearest normal, *e.g.*, in the morning and at noon, in a case of phthisis. The selection of food will be influenced by:

1. The age of the patient. For puny, badly nourished children and feeble, aged patients, a persistent effort must be made to maintain the strength of the patient.

2. The severity of the fever. An acute self-limiting fever in a robust individual warrants less anxiety, and less urgently demands the ingestion of a considerable quantity of nourishment. A high temperature for a protracted period demands a commensurate intake of nutriment.

3. The condition of the digestive and excretory organs. The diet should be entirely liquid, or semi-solid, according to the estimated condition of the digestive functions. In the exanthematous diseases, in which the kidneys may become acutely involved, an exclusive milk diet should be instituted.

Milk must be given first place as the food suitable for nourishing the sick. The curd must be modified by means of some of the methods previously indicated. The taste and digestibility may be changed by the addition of aromatics and malt extracts. The nutritive worth may be increased by the addition of egg albumen and carbohydrates, which should be given cool or warm according to the preference of the patient. It may prove more acceptable to the taste, and more easily digested, if taken through a tube. The milk intended for the patient should be kept separate from that used for other purposes, so that the quantity used in a day may be accurately determined. The evacuations should be studied to detect any evidences of failure to digest the fat or casein of the milk.

Meat should be given in a form that will prove acceptable to the patient. Clear bouillon, nutritive beef-tea, beef juice, or scraped beef must be selected according to the patient's taste and digestive power, and the stage of the fever.

Eggs will be found most valuable if only the whites are used. The yolks, however, are of service when convalescence is established and oils can be digested. They should be slightly cooked at a temperature not exceeding 180° F.

Gelatin preparations are regarded as "albumen-sparing foods," and may be secured in the form of gelatin, blanc mange, bromangelon, calves'-foot jelly, chicken jelly, wine jelly, milk jelly, and similar preparations.

In those cases in which a carbohydrate is desired, a strained cream of potatoes, peas, beans, asparagus, and similar vegetables may be employed. Cereals and light puddings, or custards, may be used.

Beverages.—First and of greatest importance is water, given in the largest quantity possible without exciting nausea. If there is irritability of the stomach, a simple carbonated water, or one combined with cracked ice and a few drops of brandy, may be found superior to champagne in allaying the nausea. Lemonade, prepared by using boiling water and straining after it has cooled, will be accepted by certain patients who cannot take it when prepared in the ordinary way. Dilute phosphoric or hydrochloric acid will be well received in some cases. The use of egg, barley, rice, oatmeal, corn, toast, and similar waters, will each in turn be found of utility. Tea and coffee, without sugar or cream, are not used as often as they might be in cases in which the contained alkaloids would not be objectionable. They have the additional advantage of possessing distinct therapeutic properties.

Alcoholic liquors are to be used only when a positive indication for them exists. They are valuable as foods and beverages, and require the minimum degree of effort upon the part of the digestive organs to utilize them. But they are not to be administered in doses larger than may be required to produce an odor in the breath some time after their ingestion. So long as the feebleness, restlessness, or sleeplessness is favorably influenced by their use, we may know they are doing good. The form in which they are exhibited is less important than is the purity of the beverage and the effect produced. In America whiskey is most used. All forms of alcoholic stimulants are less used than formerly.

Typhoid Fever.—Milk is, without question, the food best suited to these cases. This is true for the following reasons: (1) It is a complete and sufficient food; (2) it is most easily digested; (3) it is acceptable to almost all patients; (4) it is available, and its purity is easily determined; (5) it is easily modified as to taste, curd, and proportion of any constituent; (6) the dosage is easily regulated; (7) it furnishes a food which is both diuretic and diluent.

So far as can be determined milk is the food best adapted for the human race at all ages and in all conditions. The somewhat prevalent idea that a considerable number of patients cannot digest milk is not founded upon fact, the difficulty being due rather to individual peculiarity of taste than to inability to digest the milk The cases of illness in which milk cannot be made the exclusive diet, if the patient is so inclined, must be rare. The milk may be made more acceptable by modifying the taste and curd, by diluting to the extent of one part of milk to four of water, by feeding through a tube or giving a teaspoonful every minute for eight minutes of each hour, by having the patient take it from a porcelain drinking-cup and preceding and following it with a tongue bath. If, after persistent efforts of this sort, the patient is still unable or unwilling to take milk, it may be necessary to give it as whey or junket, or it may be peptonized, or sufficient oyster or clam juice may be added to it to impart a distinctive flavor. The failure of the foregoing methods for the administration of milk may necessitate the employment of nutritive beef-tea, or manufactured beef preparations, the precaution being taken to ascertain that they possess albuminous worth.

Egg water, prepared by adding eight ounces of water to the white of one egg, is serviceable. Sherry or lemon peel or juice may be added to impart flavor.

The quantity of milk to be given to a patient must be determined for each particular case. Ordinarily, three pints in twenty-four hours is regarded as sufficient for the adult who is confined to bed with an acute illness. If the patient is given six ounces of milk every two hours, from 7 A.M. to 7 P.M., and two feedings of six ounces each during the night, he will receive three pints in twenty-four hours; or if eight ounces be given every three hours during the day, and twice during the night, the same amount will be ingested. This plan insures the administration of the quantity determined upon as desirable.

The evacuations should be watched, and the presence of curds or globules of oil would demand respectively either the lessening of the quantity of milk or the rendering of the curds smaller, and diminishing the quantity of cream contained in the milk.

Constipation will be less annoying if large quantities, *i.e.*, five pints or more, of water are given daily.

Hemorrhage, or perforation, will make it advisable to withhold all milk and give meat juice only; a half-ounce may be given every hour or two. When we remember that six ounces of meat juice represent the liquid element of one pound of beef, it will be appreciated that the patient is being sufficiently nourished. The beef juice is speedily absorbed, and leaves so little residue that there is no need to have a bowel movement until a sufficient time has elapsed for the bleeding point to have healed.

If we remember that the stomach is the first to recover its function, and that it has been least involved in the morbid process, we shall appreciate the fact that the dietetic indication is to give foods requiring gastric rather than intestinal digestion. A safe and extensively adopted rule is to give milk diet until the temperature has been normal for one week, then to give the whites of eggs raw or slightly cooked. Foods such as chicken jelly, junket, pap, an entire egg, strained cream of potatoes, oysters and clams, raw oysters, ice cream, cornstarch, arrowroot, egg custard, scraped beef, baked potatoes, and similar *properly prepared* good food, should constitute the diet for at least a month after the temperature has been normal.

Acute Articular Rheumatism.—The food suitable for any acute febrile process will be acceptable in this disease. The foods containing meat in any form are to be curtailed or entirely cut off. Milk foods and cereals in the form of broths are to be given. After the fever has subsided a greater variety of broths and light custards may be given. It is preferable to secure the nitrogenous elements of the food for these cases from a vegetable source, unless it can be given in the form of casein. Broths of oysters and clams, rice or barley soup with chicken, or egg prepared in digestible forms, may be administered, unless they excite some untoward symptoms.

Chronic Articular Rheumatism.—The conditions demanding dietetic consideration are similar to those present in gout, and the diet outlined for that disease will serve in this instance (*vide* section on Gout).

Gout.—Under this head are included Lithæmia, Uricacidæmia, Gall Stones, and Renal Calculi.

Without entering into a consideration of the identity of the pathology of these diseases, it may be confidently asserted that the dietetic treatment for all is so similar that they may be considered at the same time. It is well to remember in this connection that in these cases "there is a want of balance between the intake of food and the power of the body to oxidize and utilize it." Here, as in so many conditions, the disease is not limited to one organ, but is the result of an inability of all organs concerned in food elaboration. The end product of albuminoid digestion in these cases is uric acid, which is decidedly less soluble than the urea which should be the form in which the excretion occurs. The dietetic indication in these cases is to administer the food most favorable to the maintenance of the alkalinity of the blood, thus preserving its solvent power. Ready and complete digestibility and assimilability of the food administered must always be given consideration. Moderation is a watchword for all these cases. The food must be adjusted to the age and occupation of the individual. A vegetable diet is one most favorable to these conditions, and yet it would be a serious mistake suddenly to change the dietary of an individual from one made up chiefly of meat to one entirely composed of vegetables. The red meats are especially concerned in the causation of the conditions under consideration, and should therefore be replaced to a greater or less extent, according to the amount of work being expended, with the white meat of fowls and fishes. What will prove more efficacious in a considerable number of cases is to have the patient adopt a diet from which meat is entirely eliminated.

There is great need of a more extensive and accurate study of the causal relationship existing between food and the conditions conveniently grouped under the designation "lithæmia." Two propositions that seem almost axiomatic may, however, be stated: first, most individuals eat too much food, and second, most Americans eat too much meat. It is surprising what a small amount of food will prove sufficient for the demand of the system after maturity has been attained. A close adherence to the rule that permits enough food to satisfy positive hunger and no more is the price of comfort for many lithæmia patients. Fothergill expresses this idea when he says, "there is no nice way of having gout, and what is worse, there is no pleasant way of avoiding it."

The dietetic treatment will have to be adapted to the stage of the disease. During the acute manifestation of the disease none but the lightest nourishment should be given. Diluent, diuretic, and diaphoretic drinks, milk diluted with carbonated water, thin oatmeal gruel, or similar preparations, should be given. Hot drinks are indicated.

The interval between the acute manifestations offers the most favorable opportunity for influencing the disease. The greater facility with which we secure complete metabolism of a meal composed of one or two simple foods, selected with a view of securing a complete food, would make it advisable to adopt this method in arranging the dietary for these cases. The plan pursued in the meal composed of several courses is intended to stimulate the appetite, with the result that the digestive and assimilative powers of the individual are frequently overwhelmed with uric acid, which the organs concerned are unable to excrete, and an acute paroxysm of gout results. The nitrogenous element of the food for these cases may be derived from whole milk rather than from skimmed milk, which contains a larger percentage of albuminoid. If whole milk cannot be digested, it is better that it should be diluted with alkaline water than to have it skimmed. The fat contained in the cream is of service in lessening the amount of carbohydrate that would otherwise be required. Milk is of further advantage from the fact that it will not yield uric acid in the same measure as do most other nitrogenous foods.

In those instances in which a meat-free diet is not to be insisted upon, oysters and clams may be used in a great variety of ways, and their preparation enables us to introduce large quantities of milk and water into the system. Fish of almost any variety, excepting the indigestible forms, represented by those containing a large percentage of oil,—*e.g.*, mackerel, herring, eels,—are permissible.

The white meat of fowls may be prepared in a great variety of ways, ranging from broths to the minced meat made into panada, or, if the digestive power will permit, it may be given roasted, broiled, or stewed.

Eggs slightly cooked may be used, and if they are found unsuited as food for these cases, it will probably be the yolk that has disagreed, because of the large amount of fat contained in it. The albumen of the white is very easily digested.

Cheese, representing the albuminous and in some instances the fat constituent of milk, has many of the advantages possessed by milk as a food, and may be used to furnish the albuminous element of the meal. There is less likely to be indigestion from its use if meat is excluded from the meal, of which cheese is to furnish the nitrogenous element. The constipation so frequently associated with the diet into which cheese enters is less troublesome if cream cheeses are taken. The ability to digest different varieties of cheeses varies with the individual patients. Sometimes it is necessary to begin the use of cheese in the dietary by administering casein in the form of junket, then cottage cheese, Neufchâtel, or some similar cheese rich in cream. It not infrequently requires time and persistent effort before it can become a considerable element in the dietary of certain individuals. If we desired to give a cheese poor in fat and rich in casein, we should select the Parmesan cheese. This variety may be added to broths, after it has been grated, to increase their nutritive worth, or it may be made into sandwiches, and if whole wheat or gluten bread be used, there will be secured in such a combination a food containing a large nitrogenous element. Cheese is said to be three times as nutritious as meat. One has only to remember how largely this form of food takes the place of meat in almost every country except America, and to contrast the infrequent use of it in this rôle, to realize to what great extent meat enters into the dietary of the Americans.

Fats, in moderation, serve a useful purpose in the dietary of these cases. Any evidence of inability to digest them may be regarded as a contraindication to their use.

Sugars, just as fats, are permissible to a limited extent. They must not be taken in quantities sufficient to excite indigestion or to favor the development of corpulency. So far as sugars and fats can be utilized as heat and force producers, they do good; more than sufficient for this purpose should not be ingested.

The vegetable element of the meal should be made up of one, or at most two, vegetables. If the nitrogen required is supplied in the form of meat, milk, or cheese, then the vegetable had better be one composed chiefly of starch, *e.g.*, potatoes or rice. When peas or beans are used the contained nitrogen will furnish a portion of that required for the meal.

The green vegetables, so long as they do not excite indigestion by reason of their bulk and woody fibre, are allowable.

Cereals, when properly prepared and thoroughly insalivated, may form a part of the morning and evening meal.

Macaroni and vermicelli, arrowroot, corn starch and bread, offer convenient and digestible forms of starchy food.

Fruits suitable to these cases must be neither too sweet nor too tart.

All forms of food for these patients must be studied with reference to the effect produced on each case. The more nearly we accurately estimate the need and ability of a given case to metabolize various kinds and quantities of foods, the more likely we are to get satisfactory results.

Beverages.—Water stands first, and might with advantage be made the exclusive drink. Water, plain or medicated, hot or cold, should be used in large quantities to secure its mechanical and solvent effect upon the excretions. The most favorable time for its ingestion is a half-hour or an hour before, or several hours after a meal.

Tea, coffee, cocoa, cider, port, champagne, and malt beverages are not usually permissible. For those who require it, a light wine, poor in sugar and alcohol, if diluted with carbonated water, may be administered. Moselle, Bordeaux, claret, or Hungarian wines are permissible.

If a spirituous liquor is required, whiskey, brandy, or gin, well diluted, may be given.

The foods prohibited are those containing oxalic acid in considerable amount, *e.g.*, rhubarb, spinach, tomatoes, asparagus, sorrel, and radishes; neither must patients take spiced or dried meats, pork, bacon, veal, game, eels, mackerel, salmon, or lobster, or rich gravies, pastries, and candies.

Diabetes.—The dietetic treatment of this condition demands a painstaking and systematic estimate of the amount of sugar being eliminated by the patient. There is no other disease in which the relation of diet to the activity of the morbid process is so intimate. Anything less than the most detailed attention to the ingestion of food, and the excretion of sugar in the urine, is an act of censurable neglect. It can be readily appreciated that the selection of alimentary substances is of no more importance than their proper preparation. A condition demanding, for a protracted period, a diet composed of articles from which an entire class of foods—*i.e.*, carbohydrates—must be eliminated requires the greatest skill and ingenuity on the part of the one to whom the preparation of the food is entrusted. It is not enough to hand to a patient suffering with this disease a list of the foods allowed and those to be omitted. Here, more than in any other condition requiring dietetic direction, is there need to demonstrate to the patient the possibilities of the curtailed regimen permitted him. There must be a thorough understanding between the doctor and the cook as to what is to be attempted, and that the starches and sugars are not to gain entrance into the dietary in any form. For instance, it would not be permitted to use wheat flour as a thickening in soups when we had forbidden wheat bread in order to eliimnate starch.

Before beginning the dietetic treatment of this disease certain facts should be determined as a result of observations extending over several days. The quantity of urine voided and the percentage of sugar contained in it; the diet yielding these figures; the weight of the patient and his strength, as evidenced by tests with the dynamometer or graduated work; all require careful consideration. After this has been done the capacity of the organism to metabolize carbohydrates should be determined. The plan suggested by von Noorden, according to which the patient is gradually placed upon a standard diet, may be recommended (Yeo, "Food in Health and Disease," p. 376).

Von Noorden's Standard Diet.—After the carbohydrate element of the diet has been gradually reduced the following diet is administered:

Breakfast: Tea, 5 gm. infused in water 200 c.c.; ham, 150 gm.; one egg.

Lunch: Cold roast beef, 200 gm.; cucumber, 60 gm. with vinegar (5 gm.), olive oil (10 gm.), salt and pepper (to season); Apollinaris water, 400 c.c. with brandy (20 cm.); coffee, without milk or sugar.

Dinner: Clear boullion, 300 c.c.; beef, 250 gm.; butter, 10 gm.; green salad, 80 gm.; vinegar, 10 gm., and olive oil, 20 gm.; sardines, 3; Apollinaris, 400 c.c., with brandy, 20 c.c.

Supper: Two eggs; Seltzer water, 400 c.c.

This diet contains about 204 gm. of albumin, 135 gm. of fat, and no carbohydrate. It is to be continued until there is an absence of sugar from the urine in the one instance, or until it demonstrates the amount of sugar being formed despite the absence of carbohydrate in the food ingested. This method yields a basis for the classification of these cases, and is of further advantage in enabling us to determine the ability of the economy to metabolize varying amounts of carbohydrates in those cases in which there was an absence of sugar from the urine after the patient had been upon the "standard diet" for a sufficient length of time. A patient whose urine shows no sugar for several days as a result of the carbohydrate-free diet, is allowed some form of starch, in gradually increasing quantities, until sugar reappears in the urine.

The following formula will then express his power to metabolize starch: tolerance to starch = standard diet + x grains of starch.

The gravity of the disease is proportionate to the amount of sugar persisting, notwithstanding the administration of the "standard diet." In the cases in which sugar appears in the urine despite this diet, we are given a measure of the transformation of the albuminoid tissues and fats into sugar.

The indications in regulating the diet of diabetic patients.—In the withdrawal of the carbohydrates, the economy being denied the usual supply of carbon for the production of heat and force, it becomes necessary to supply a sufficient increase of fat for this purpose, and greatly to augment the intake of nitrogenous food for the same purpose. The dietary permissible to these patients includes all meats, excepting liver, which latter, because of its contained glycogen, is not suitable; and fats, which are called the sheet anchor by von Noorden, and which, in addition to their nutritive worth, are esteemed because they tend to produce a feeling of satiety, and thus relieve the distressing hunger so frequently a prominent symptom in these cases. They in a great measure supply the deficiency of carbon resulting from the withdrawal of the carbohydrate. The administration of fat requires the greatest care lest a disgust for it be excited. It can be introduced in the form of a thin layer rolled in a slice of roasted beef, or between bits of broiled beef; as a mayonnaise dressing on various salads; as butter spread very thickly upon almond biscuit or gluten bread; in the form of gravy of fowls; in the form of meats containing a large proportion of fat, *e.g.*, mackerel, eels, blue fish, salmon, sardines, squab, and the dark meat of fowls; and ripe olives. Some writers also allow paté-de-foie-gras. The problem of successfully feeding a diabetic is largely one of skilfully administering in acceptable manner the various meats and fats. To these articles may be added a moderate allowance of green vegetables containing a minimum amount of starch, and possessing vegetable salts, the latter being of value for antiscorbutic purposes.

Meats may be given in any readily digestible form, such as beef in the form of broth; scraped meat cakes suitably seasoned, to which may be added chopped almonds, pine nuts, or celery; cold boiled ham; crisp broiled bacon with eggs; chipped beef creamed, or as a sandwich with gluten crackers; tongue, kidneys, tripe, sweetbreads, calves' brains, smoked meats, and game of all kinds.

Fish of all kinds may be employed, as, for example, oysters, omitting the liver; clams, lobster, crabs; caviare, plain, or combined with a few drops of grated onion in the form of a sandwich of gluten bread or diabetic biscuit.

Milk is of service in certain cases, the sugar of milk being less likely than most other forms of sugar to favor the development of glycosuria. *Cream* is of especial utility, containing as it does an albuminoid and a fat. It may be given plain, combined with various flavors, whipped, frozen, or in conjunction with white of egg. *Skimmed milk* has been urged by various writers, large quantities, as much as from nine to twelve pints daily, being urged by Donkin, who reports favorable results from its use. He points out that in this form milk offers a concentrated assimilable albuminoid. Part of the milk recommended is to be taken in the form of coagulated casein. Koumys, zoolak, and buttermilk may be found acceptable and unobjectionable in certain instances.

Cheeses prepared from cream are less likely to increase the amount of sugar present than are those prepared from the whole milk. All forms of cheese may be utilized in certain instances.

Eggs offer an ideal food because of the albuminoid and large percentage of fat contained in the yolk. Given cooked or raw, with a little salt to facilitate their digestion, they lend themselves to innumerable methods of preparation, and may be consumed in large quantities.

Gelatin, if regarded as an "albumin-sparing food," should be of utility. It may be given in a great variety of ways, such as in the form of milk jelly, blanc mange, chicken jelly, calves'-foot jelly, and similar preparations.

The vegetables allowable comprise most of the greens: lettuce, cress, spinach, cabbage, asparagus, onions, cauliflower, cucumbers, dandelion; also cranberries, gherkins, artichokes, horseradish, kale, green French beans, pickles, carrots. Potatoes are allowed by some as a substitute for bread, because the percentage of starch contained is smaller than in ordinary bread. If potato be given in the form of a salad, with mayonnaise dressing and onion, or if it be baked and butter and egg added, it should possess special nutritive worth.

Fruits containing little sugar, preferably those containing it in the form of levulose, are permissible, *e.g.*, apples, strawberries, gooseberries, currants, raspberries, sour oranges, and lemons.

Nuts of all kinds, excepting chestnuts, may form a large element in the dietary. They furnish a form of food that may be used extensively by varying the method of administration. If the patient picks the nuts from the shell he is apt to enjoy them more and is less likely to partake of them too freely. In other instances they may be administered after they have been ground in some one of the machines now upon the market for this purpose. This method of preparation overcomes the tendency to rancidity so pronounced in the nutmeals upon the market. Roasted and salted nuts are often particularly appetizing and sometimes aid digestion.

Forbidden Foods.—The forbidden foods comprise all saccharine or starchy vegetables and fruits, as well as the livers of animals and oysters *Bread* is not permitted except in the milder cases, where it should be "torrefied" or twice baked.

Gluten bread is certain to contain not less than fifteen per cent. of starch, and usually the amount is much greater. It is heavy, and patients not infrequently refuse to eat it. It is well to learn the possibilities of the various manufacturers' products of biscuit of gluten, almond meal, and similar food substances which are likely to contain less starch than is contained in gluten bread; they are quite palatable and keep indefinitely.

The *sweetening* required is to be secured by the use of saccharin. This substance is likely to excite indigestion, and must be used in the smallest possible quantities. There are tablets on the market containing one grain of saccharin, which offer the substance in a convenient form. Glycerin is recommended for sweetening purposes by some writers.

Beverages.—If alcoholic beverages are required because they have become essential to the patient, they should be confined to a dry or tart wine, such as Moselle, claret, hock, or Burgundy; brandy, whiskey, or gin may have to be given, and all beverages should be well diluted with an alkaline or carbonated water. Study the effects of particular wines upon a given case and regulate their administration accordingly.

Tea, Coffee, and Cocoa. Tea may be given, preferably with lemon; coffee, without milk or cream. Cocoa nibs and chocolate prepared without sugar may be used. The "*water cures,*" notably those of Carlsbad, combine with the therapeutic effect of the water administered, a favorable environment, a suitable adjustment of food and exercise, medicated baths, massage, and an absence of the exciting causes that have been potent as factors in the production of the disease.

For one to whom so much is denied it is worth while to consider the possibilities of a daily mênu consisting only of the foods permissible. Such a dietary would comprise for one day:

Breakfast: Poached eggs and bacon; gluten bread; cream and hot water.

Luncheon: Cream of spinach; hot sardines on gluten biscuit, garnished with lemon and parsley; celery salad with mayonnaise; tea with lemon.

Dinner: Little Neck clams; consommé; roast beef; asparagus with melted butter; stewed onions; lettuce with French dressing; junket; coffee.

Nervous Affections.—Neuralgia has been defined as "the cry of a hungry nerve." The pain may be associated with the trifacial, gastric, hepatic, intestinal, or other nerves, and the neuralgia may be designated accordingly. If traumatic irritation has been excluded as an exciting cause of the condition, it is of importance to determine the degree of nutritional failure that is likely to be present in a particular instance. The intimate causal relationship between nerve pains and lithæmia or uricacidæmia, would lead one to endeavor to determine how far an excess of foods containing uric acid is concerned in the production of the neuralgia. Indeed, it would seem justifiable to regard neuralgia as a symptom; it may be of anæmic, lithæmic, gouty, rheumatic, or dyspeptic conditions, and these each, in turn, may be regarded as the products of faulty nutrition. Therefore the principles underlying the dietetic treatment of one condition will apply to all.

First, the habits of the individual must be studied. The food he has been accustomed to take, the care exercised in its preparation, the regularity in eating, and the suitability of the quantity and kind of food to the life work of the individual must be ascertained. A good practice in these, and in similar cases, is to have the patient continue, under observation, for a time without any dietetic restraint. Let a record of each meal be made and submitted for inspection, and in this way it is often possible to discover a potent factor in the causation of a morbid condition. It is well, however, to guard lest a patient in moderate circumstances should bring a list of fare so sumptuous as at once to disprove its accuracy.

The study of the urine, with special reference to the amount of uric acid being excreted, will yield most valuable data regarding the advisability of withholding certain albuminous foods. One cannot study Haig's work on this subject without being impressed with the intimate relationship existing between an excess of uric acid and certain neuralgic manifestations. Indeed, it is hardly possible to determine how far gout, rheumatism, and calculous diseases in general are dependent upon this same condition of uricacidæmia.

That diet is a potent factor in the successful treatment of all these processes is universally accepted. Therefore it is in order to consider what foods will give us sufficient of the various elements necessary for nutrition, and at the same time leave no excess of uric acid in the circulating blood.

The gradual withdrawal of all forms of meat from the dietary, with a proportionate increase of milk, cheese, and gluten foods to supply the nitrogenous food required, and a corresponding increase in the starches, nuts, and fruits, is recommended. No better example of this plan can be given than is found in the tables suggested by Haig (Tables 1, 2, and 3 on page 460).

It is not to be inferred that the dietary is to be limited to the articles suggested in these tables. Indeed, it is surprising to note what a variety of meals can be prepared without meat and the forbidden foods. On the other hand, certain patients find it entirely impracticable to live upon this or a strictly vegetable dietary. In these instances the liberal administration of beef in the form of nutritive beef-tea and scraped or chopped meat cakes, in conjunction with a decided increase in the fats, will give the best results. The fats suitable are obtained in cream, butter, bacon, and in the yolks of eggs, in the form least likely to tax digestion and excite repugnance.

When all the exciting causes of the disease under consideration are eliminated, the diet which maintains a condition of nutritional equilibrium will be the one best suited to the case.

Neurasthenia requires an excess of easily assimilable, highly nutritious food, administered at frequent intervals, in the largest possible quantities. This particularly applies to those cases undergoing what is usually designated "the rest cure." Here the food is urged upon the patient regardless of his desires, and even despite a positive disinclination for food. Milk, cream, and other forms of fat and oils, gruels and easily digested starches, are administered at frequent stated intervals, and the patient is aided in utilizing a part of this nutriment by the administration of massage and electricity, while he stores the remainder in the form of fat and muscular tissue. Indeed, the entire plan of the treatment aims to secure a marked increase in body weight. This is in accord with the view expressed by S. Weir Mitchell, who states that "loss of fat is constantly associated with impoverished blood, and that to gain in fat is nearly always to gain in blood." Many cases of neurasthenia which do not undergo the rest cure are greatly benefited by an ocean voyage, where there is usually a condition of limited expenditure of mental and muscular effort, coupled with an inclination to ingest and ability to digest excessive quantities of food. A neurasthenic who travels for his health should not be allowed to consume, in long journeys, irregular meals, and hasty sightseeing, all the energy developed from his ability to take increased quantities of food.

Insomnia is frequently referable to one or two classes of causes:

(*a*) Improper eating or drinking before retiring.
(*b*) Deficient nutrition.

The patients of the first class require only to have the food, drug, or drink that has been causing the insomnia to be cut off, and to have the evening meal composed of easily digested food. This, with the temporary use of a hypnotic, should accomplish a cure.

In the second class of cases an effort should be made to place the patient upon a higher nutritive level by the administration of light nourishing food between meals, and a cup of hot milk, a milk punch, or malt beverage with a biscuit before retiring. A complete food, such as "Bartholow's food," taken before retiring, will frequently insure a night's repose. It is desirable to have some milk or crackers at the bedside, in case they should be required during the night. The objection to liquors and malt beverages, as an aid in inducing sleep, does not apply to this class of cases as it does to the cases of insomnia occurring in youth.

Epilepsy is so rare in the herbivora, and so frequent in the carnivora that the immunity of the vegetarian animals would seem to give us a positive dietetic indication for the treatment of this disease. The red meats and coarser forms, such as bologna, seem to be especially prone to excite convulsive attacks. Gorging with food, especially improperly masticated meats and other forms of nourishment—notably peanuts—are noted as being likely to excite epileptic paroxysms.

The intimate relationship between the ingestion of an excess of unsuitable and improperly masticated food and an epileptic seizure must be familiar to all those who have given considerable attention to this class of cases. The dietetic treatment of epilepsy promises most when the patient is under the complete control of an attendant. For this reason the epileptic colonies should secure the best results, other things being equal.

The diet that promises most for these cases is one in which meat is reduced to the lowest quantity consistent with the demand for work and growth. In early youth and old age, fish and white meat, with the occasional administration of red meat for the noon meal, are best. Aside from this, the diet should consist of cereals and vegetables, and the meals should be eaten at fixed hours. The frequency of the attacks during the night would suggest the desirability of having the evening meal composed of easily digested food.

Exanthematous Diseases.—The diseases characterized by a skin eruption in the course of an acute febrile process will demand especial dietetic direction only in those instances in which nephritis has occurred as a complication. Here milk is to be made the exclusive nourishment, until the absence of albumin from the urine indicates the improved condition of the kidneys and permits a more extended dietary.

Skin Diseases.—These, when not of parasitic origin, are frequently influenced by diet. The causal relationship between the occurrence of urticaria and the eating of certain fish, molluscs, fruits, or cereals is fully established. Certain cases of eczema, acne, psoriasis, furunculosis, dermatitis, and pruritus can be favorably influenced by attention to the character and quantity of the food. That there is found associated with indigestion and lithæmic states a condition favoring the development of skin eruptions, there can hardly be any reasonable doubt. The diet outlined for lithæmia will be found suitable for these cases (*vide* section on Gout).

B. Franklin Stahl.

DI-ETHYL-KETONE.—$(C_2H_5)_2CO$, metacetone or propione-ethyl propionyl. This is a colorless, mobile liquid obtained by the dry distillation of sugar with an excess of lime. It smells like acetone, boils at 101° C., and is soluble in twenty-four parts of water, and freely in alcohol and ether. Well diluted, it has been administered by Giovanni in doses of from 0.5 to 1.5 gm. (gr. viij.–xxiv.) to control maniacal or hysterical excitement, and by Albanese and Barabini to induce sleep in animals.

W. A. Bastedo.

DIFFERENTIATION.—(Med. L. *differentiare*, from *differentia*, difference.) Murray defines *differentiation* as "any change by which like things become unlike, or something homogeneous becomes heterogeneous." In the more special, biological, use of the term it is employed to indicate "the process, or the result of the process, by which in the course of growth or development a part, organ, etc., is modified into a special form, or for a special function; specialization; also the gradual production of differences between the descendants of the same ancestral types." In its biological meaning, then, the term may be applied either (1) to certain phenomena in the development of the individual, or (2) to the origin of species; and in each case it may be used to indicate either (*a*) the process, or (*b*) the result of the process.

Taking these meanings in the reverse order, the result, or state, of differentiation of species (2, *b*) would be exhibited by a comparison of the various organs, tissues, habits, modes of life, and other characters of the numerous species and other groups of both animals and plants. It would involve not only a study of their comparative anatomy, but also of their physiology and ecology as well; and thus would be far beyond the scope of the present article.

For the differentiation of species regarded as a process (2, *a*) the term *organic evolution* is commonly employed, and the subject will be discussed in the present work under that title (see article *Evolution*).

In the individual, as among species, the state of structural differentiation (1, *b*) is inseparably associated with functional differentiation, or division of labor. In order to describe the state of differentiation in any form of animal or plant, it would be necessary to make an extended study of the structure of its various organs and tissues and of the various functions that these parts perform in the economy of the whole. For man the results of such studies are set forth in the books upon descriptive anatomy, histology, and human physiology.

The *process* of differentiation by means of which differences arise in the structure and functions of parts of the organism (1, *a*) may be considered under two headings. First, we have the facts in regard to the processes that have been observed in the study of the development of organisms; and, second, we have the theories that have been advanced to explain these facts.

In no existing form of life is there an entire absence of the state of differentiation in any stage of development of the individual. In the protoplasm of the amœba one may distinguish endosarc and ectosarc, nucleus, and contractile vacuole. The protoplasm of bacteria was supposed for a long time to be homogeneous; but Bütschli has demonstrated that by proper methods of staining two distinct substances may be observed. In the germ cells of all the higher animals and plants it is always possible to distinguish nucleus and cytoplasm. In the ova of many animals the cytoplasm is differentiated into two parts: one which contains nutrient material in the form of yolk granules, and the other which is free from yolk, and in which the process of development begins;—not to mention various differentiations in minute structure which cannot be entered into here. The ovum, however, is vastly less differentiated than the adult form, even in the simplest of multicellular organisms.

The process by which the differentiated condition of the adult arises is essentially a cellular phenomenon. In general, development may be divided into three stages: first, cell division; second, growth by the absorption of water and other material; and, third, differentiation. These stages are shown in their simplest forms in the growing ends of the roots or stems of plants. At the tip there is a group of small cells with thin walls and relatively dense protoplasm, in which the nuclei may be seen to be in various stages of cell division. Separated from these by cells in various intermediate stages, there is a zone of cells still having thin walls, but which are much elongated and have numerous large vacuoles in the cytoplasm. In this zone cell division is comparatively rare. It is the zone of growth, and on its proximal side grades off into the next zone, where cell division entirely ceases, the cell walls become thickened, and the cells become differentiated into epithelium, bast, wood fibre, ducts, etc.

In animals the process is not so simple, nor is it always so in plants; for in reality there are two forms of differentiation occurring more or less at the same time. One we may call *anatomical differentiation*, and the other, *histological differentiation*.

During the periods of cell division and growth the cells do not all divide with equal frequency, nor do they all enlarge to the same extent. When the cells tend to arrange themselves in layers, as they do in animals, this inequality of growth causes foldings, the folds may fuse together, and old connections may dissolve. In this way unequal division and growth of the cells, resulting in folding, fusions, and separations, cause a differentiation of the mass of the ovum, whereby the areas are determined which shall include the rudiments of the various organs. In the embryo chick, for example, one may see the boundaries of the central nervous system, the notochord, the heart, etc., while the cells composing these rudiments are still in the most embryonic condition and cell division is going on rapidly. Thus, anatomical differentiation begins in very early stages of development, and precedes the process of histological differentiation, which results in the modification of the cells so that they may form the tissues appropriate to the organs or parts of organs in which they lie. (Further details in regard to the facts of differentiation may be found in the articles *Area Embryonalis, Fœtus, Gastrula, Germ Layers, Segmentation of the Body*, etc.)

When we come to consider the conditions under which individual differentiation takes place, we see at once that these may be divided into two categories. For example, we may take an egg of a sea urchin and an egg of a star-fish, small transparent eggs not very different in size or general appearance and yet sufficiently unlike to be easily recognized. These, placed together in a bowl of clean sea water of the necessary temperature, and containing sufficient oxygen, will proceed to develop into larvæ; and, although the conditions of the environment are exactly alike for both eggs, one will become the larva of a sea urchin and the other the larva of a star-fish, according to the source of the egg. Or, again, consider a new-born litter of puppies. They are out of the same bitch, have been sired by the same dog, have undergone development at the same time in the same uterus. Yet these puppies will be sufficiently different so that each one may be recognized easily. On the other hand, any puppy in this litter will resemble the others and both parents more closely than will any puppy out of a similar litter dropped by any other bitch and sired by another dog. It is evident that there is something inherent in the germ cell that causes differentiation to proceed in a certain way more or less independently of surrounding conditions. Moreover, the resulting peculiarities of the offspring are correlated with the peculiarities of the parents at the corresponding stages of development; but the correlation is not perfect.

That the course of differentiation is not entirely independent of external conditions, but, on the contrary, is strongly influenced by them, may be shown by a number of experiments. For example, take seeds of two kinds of plants, say a bean and a petunia, and plant them side by side under the same conditions of soil, temperature, and moisture, and exclude all light. The seedlings will develop with long, slender stems, and small, yellow leaves. Seedlings of the same plants grown in full sunlight, other conditions being the same, will have shorter and thicker stems, and larger dark-green leaves. Here we see that seedlings of two kinds of plant have certain characteristics in common which are correlated with the presence or absence of light while differentiation is in progress. Nevertheless in each case one plant is always a bean and the other a petunia, according to the seed from which it has arisen.

We see, then, that differentiation is influenced by two sets of factors,—an internal and an external. The correlation between parent and offspring that is associated with the *internal* factor is what is ordinarily meant by heredity, and as various theories of heredity involve a consideration of the internal factors of differentiation, they will be most conveniently discussed under that title (see article *Heredity*).

The study of the *external* factors which affect the course of growth and differentiation is a new branch of biological science, called experimental morphology, developmental mechanics, or the physiology of development. Investigation in this line has only just begun, and therefore but little is known in regard to the influence of the external conditions and as to their importance relatively to the internal factors. Enough is known, however, to show that their importance is very great.

A few experiments may be mentioned to illustrate the methods that have been employed in attempts to solve this problem. The experiments will be classified according to the external condition that has been investigated.

Gravity.—A number of experiments have been made which show that in some animals the planes of cleavage in the early stages of the division of the egg are determined by the direction of the force of gravity. For example, Pflüger found that if the egg of a frog be fixed so as to prevent rotation, the first two cleavage planes would be vertical in whatever position the egg might be placed, and the third cleavage is generally at right angles to these and nearer the pole of the egg which is held uppermost. In order to obtain perfect embryos, however, it is necessary to have some part of the black hemisphere on the upper side.

It is impossible, of course, to increase the force of gravity. But the same effect may be obtained by placing an object in a centrifugal machine. Hertwig found that by rotating frog's eggs in a centrifugal machine he was able to change the style of cleavage from a holoblastic to a more or less mesoblastic type (see article *Segmentation of the Egg*), so that at the end of twenty-four hours the egg would resemble a hen's egg in having a blastoderm consisting of small cells enclosing a blastocœl and a large undivided yolk containing a few nuclei which lie close under the blastoderm.

Loeb found that the direction of gravity is a factor in determining the differentiation of parts in certain hydroids. Thus, part of a stem of Antennularia being suspended in its normal position in sea water, a new stem will grow out from the upper end and new stolons will appear at the lower end. But let the position be reversed. Then the base, which is now uppermost, will produce the new stem, and stolons will grow from the apex, which is pointing downward. The effect of gravity is still further shown by placing a piece of the hydroid in a horizontal position. Then the ends of the lateral branches on the lower side grow out in the form of stolons, while new stems appear on the upper side.

Contact.—Contact with foreign bodies has been found to influence the differentiation of tissues in the hydroids. Experimenting with Margeliss and Pennaria, Loeb found that parts of the stem in contact with the glass of the aquarium, even the apical end, would produce stolons; while all parts freely surrounded by sea water would produce hydranths. Similarly, Miss Peebles discovered that pieces of the stalk of Hydractinia and Podocoryne form stolons instead of hydranths if left undisturbed in contact with some hard substance.

When the cut surfaces of hydroid stems, either of the same individual, or of different individuals of the same species, or of different species, are held in contact, they may unite and form a graft, as in plants; and Crampton has shown that the same thing may be done with the pupæ of moths.

Stress and Strain.—Mürthle has shown that a certain amount of pressure and strain is necessary for the proper development of bone. Hermann von Meyer and Culmann discovered that the lamellæ in the spongy portions of the long bones of mammals are arranged with definite relation to the direction of the stresses to which the bones are normally subjected; and Julius Wolff found that, when the direction of stress is changed as the result of dislocation or disease, the lamellæ that are no longer in the lines of pressure or strain will dwindle and new ones will be formed in the positions where they are needed.

Light.—On the higher green plants prolonged darkness induces abnormal growth. The stems are not only greatly elongated, but the supporting tissues are imperfectly developed, so that the stems are soft and tender. The leaves are small and narrow and not fully extended. Even partial shading may result in alteration of the histological structure of leaves, as Stahl found from the study of the leaves of beech trees. A leaf that is fully exposed to the sunlight has under the epidermis on the upper side a layer of very high and narrow palisade cells closely packed together; below this there are one or two layers of similar cells, and the lower third of the leaf is occupied by a rather compact spongy parenchyma. In a leaf that has grown in deep shade, on the other hand, there is but a single layer of short conical palisade cells separated by wide interstitial spaces; and more than half the thickness of the leaf is due to a layer of loosely connected star-shaped parenchyma cells. Between these two extremes various intermediate grades may be found according to the amount of light received by the leaf.

There is not much known about the effect of light upon differentiation in animals; but Poulton found that the color of the pupæ of certain butterflies depends upon the amount of light reflected from surrounding objects at the time that the caterpillar becomes fixed; and Loeb and Miss Peebles found that the presence or absence of light has a certain amount of effect upon the regeneration of the hydranths upon the cut stems of hydroids.

Temperature.—That heat has a marked effect upon the rate of growth is well known, but little has been ascertained as to what effect it may have upon differentiation. We have, however, the interesting experiments of Weismann and of Edwards, who have shown that in several species of butterflies, where there are several broods in the course of the year with different markings, the differences of color depend upon the temperature to which the pupa has been subjected.

Chemical.—For normal development a normal chemical environment is of the greatest importance. A mere trace of some substance may be all that is necessary for normal development that will not occur in its absence. And, on the other hand, the presence of some substance not normally present may so disarrange the processes of development as materially to alter the character of the organism. Thus a trace of a soluble iron salt is necessary for the development of a green plant. Without it, not only is the green coloring matter absent, but the protoplasmic chlorophyll bodies also fail to appear. Knop experimented with Indian corn, treating it with sulphite of magnesium, and he obtained plants so modified that they had lost the distinctive characters of the genus Zea.

Wagner, Gies, and Kassowitz, by feeding young animals with minute doses of phosphorus (0.0015 gm.) and arsenic (0.0005 to 0.001 gm.), produced striking alterations in the formations of the bones. The normal fusion of the cartilage with the young bone was hindered, and in the epiphyses, instead of spongy bone, there was produced a very peculiar compact bone. In the shafts of the long bones the formation of the medullary space was hindered so that the walls of the bone became very thick and heavy.

The Pluteus larva of a sea urchin is normally provided with eight arms, which carry a band of cilia and serve as locomotor organs, and these arms are supported by a calcareous skeleton. Herbst found that a trace of potassium nitrate added to the sea water in which the larvæ are reared will prevent the formation of both skeleton and arms. Pouchet and Chabry obtained the same result by the more obvious method of rearing the larvæ in sea water from which the calcium salts had been removed. Of course, in this case the skeleton could not form from lack of material, but it is interesting to note that where the skeleton failed the arms failed also.

Another and more remarkable modification of the Pluteus was obtained by Herbst by adding a trace of lithium chloride to the sea water. In this case, the so-called lithium larva, the endoderm turned outward, instead of being invaginated in the normal way. Loeb obtained the same result by simply diluting the sea water, which would seem to indicate that the action of the lithium salt in some way interferes with the normal osmotic properties of the cells.

Finally we may mention the remarkable experiments made many years ago by Schmankewitsch upon Artemia, a small crustacean inhabiting the brine of salt works. By rearing these creatures for a number of generations in water of different degrees of salinity he was able to obtain diverse forms which had been regarded formerly as three distinct species, and one of them had been given a separate generic name.

Mixed Conditions.—There are cases in which it can be shown that change of environment induces a change in the organism, but the nature of the former change is so complex that the exact factors cannot be determined. For example, aquatic plants have certain characteristics of structure that distinguish them at once from land plants. Now there are certain plants that live with their stems partly in water and partly in air. In such plants the submerged portions have the character of aquatic plants, while the aerial portions have that of land plants. Here it is impossible to tell how much of the difference is due to the chemical or mechanical effect of the water, the freer access of oxygen, differences in light, temperature, etc.

Food.—Finally, it should be noted that the relative abundance of food has been shown in some cases to have an effect upon the differentiation of sex (see article *Sex*).

These experiments taken as a whole are of great interest because they make it evident that external conditions play a very important part in the normal differentiation of organisms, and they give us some idea, although a very imperfect one, as to what these conditions are and as to how they act. Little progress has been made in experimentation in this direction upon the higher mammals; but we do know that in these forms the presence of certain internal secretions, such as those derived from the thyroid gland, the suprarenal bodies, and the testes, are necessary in the later stages of development in order that normal differentiation may take place; and we may infer that the various factors, such as gravity, pressure, contact, light, heat, and various chemical substances, which have been found in the lower animals and plants to aid or to hinder the normal course of differentiation, may have a similar influence upon the life history of the higher mammals, mankind included.

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DIGESTANTS are defined as "remedies that aid digestion." The purposes of this article will probably be best subserved if in treating the subject we keep close to the terms of the definition, for it might lead us too far afield if we should undertake to discuss all the various appliances or agencies which exert a favorable influence on digestion. For instance, exercise in one form or another distinctly aids digestion; the use of the thyroid extract immensely improves the nutrition of the cretin, or sometimes a brisk emetic, by relieving the stomach of a task that it is unequal to, will presently enable it to resume its proper function; but no one of these three would properly be called a digestant.

The principal remedies, then, that we must consider are those which act in the stomach and intestines, and we shall try to group them according to their supposed action and the faults of digestion they are severally believed to meet.

Bitters form a numerous class, many of which, such as cinchona and its salts, and hydrastis, possess other properties besides their bitterness, which do not concern us here. Among the best known are calumba, quassia, gentian, orange, cinchona, nux vomica (with its alkaloid strychnine), hydrastis, hops, condurango, and salicin. When taken into the mouth they, especially if administered in the form of a tincture, increase the flow of saliva, but their special use is in promoting the appetite or relish for food, which is essential to normal digestion. Consequently it is customary to give them before eating, and they are the efficient ingredients of the various "bitters," technically so called, often used in clubs and barrooms as a fillip to the stomach. The effect of these drugs is increased by various aromatics, as in the case of the compound tincture of cinchona. Strychnine, while acting like the other bitters, is believed to be absorbed chiefly from the intestine.

Carminatives.—In this class belong many spices, such as cinnamon, cloves, ginger, cardamom, also black pepper and capsicum, mint, anise, with hydrocyanic acid, chloroform and its preparations. All of these have a decidedly aromatic flavor with, in some instances, a sharp or stinging taste. Many of them have long been used as domestic remedies in the shape of teas, in which the hot water probably did the most good, while the aromatic flavor made it possible to take and retain a large quantity. The ingestion of them is usually followed by eructations of gas. They are used in cases of flatulent distention without inflammation and when there is no marked irritation of the stomach and bowels.

Alcoholics include the different wines in common use, spirits such as whiskey, brandy, and gin, as well as those strongly alcoholic and aromatic syrups called cordials, among which are curaçao, maraschino, Kümmel, and others. They are most widely recognized and popularly used both as direct aids to digestion when it is not seriously at fault and as a ready help in time of great trouble from conditions similar to those in which carminatives are indicated. Their heating and stimulating properties on such occasions relax the spasmodic contraction of the muscular fibres of the intestinal walls so that regular peristaltic movements can again take place, the painful distention is removed and the confined gases are dispersed or expelled. The value of small quantities of diluted alcoholics in promoting or diminishing the activity of digestive processes, especially in the stomach, is not yet apparently definitely determined, and probably varies according to individual conditions or peculiarities, for the observations and experiments of physiologists of equally good standing are mutually contradictory (Cushny).

Cathartics certainly come within the terms of our definition, for imperfect and irregular action of the bowels is one of the most fertile causes leading to indigestion, albeit the ways in which cathartics act as aids to digestion are various and often remote. Their number is so great that it will be impossible to do more than name a few classes or individual drugs, the action of which is most directly connected with the best-known digestive functions, leaving out of consideration such as, *e.g.*, the drastics and hydragogues. True, so practical a writer as Fothergill tells of a pill of the following composition given to a man twice daily for two months with benefit to his digestion, viz.: Ol. croton., ♏i.; gamboge, gr. iss.; pulv. capsici, gr. i.; strychnia, gr. $\frac{1}{60}$; Ext. aloes aquos., q. s.; but most patients are more helped by milder doses. He also quotes Lauder Brunton to this effect: "Purgatives prove useful in many ways. They hurry the food out of the alimentary canal, and thus lessen the injurious effects of over-eating. By expelling irritating substances from the intestine they arrest diarrhœa and remove headaches and other pains, caused either by the abdominal irritation or by the absorption of poisonous matters produced by imperfect digestion and decomposition of food." Thus it is enforced that cathartics are important aids to digestion alike when the disturbance is evidenced by constipation and by diarrhœa. Another condition in which the cathartic aids digestion is when the walls of the atonic or dilated stomach are covered by a coating of thick tenacious mucus, which also covers the bolus of food. The familiar morning draught of hot water, or the hot saline draught before breakfast, helps to liquefy and sweep away this mucus and leave the way unobstructed for the gastric secretions to reach the food. The natural saline mineral waters in all countries are immensely popular both with the profession and with people at large, and are perhaps the most largely used of all cathartics, whether taken habitually to secure a daily movement of the bowels or as a principal feature of occasional or periodic visits to the spas. No doubt, on the latter occasions the mineral waters themselves receive more credit than they deserve for the improved digestion, much being undoubtedly due to the influence of change of air, to regulated exercise and diet, to rest from customary labors or indulgences, and in some degree to the various external applications of the waters. Salines, other than as ingredients of the natural mineral waters, belong among the purges. The most important of them are sulphate and citrate of magnesia and sulphate and phosphate of sodium and, like castor oil, rhubarb, mercury, aloes, and senna, they promptly unload the bowel. The less active remedies, the effects of which are chiefly manifested on the lower bowel, include such as manna, sulphur, and cascara, and are classed as laxatives (Wood). It would be in vain to enter on a discussion of the many other cathartics, for the theories both of their many desirable combinations and of the ways in which they do good in the digestive system alone would fill volumes. One other method of treatment deserves attention at this point and that is *lavage*. Although it is essentially an evacuant, yet so good an authority as Hemmeter says: "Lavage, with solutions of sodium chloride, or of 0.04 per thousand of HCl, is most effective in starting the sensation of hunger." He specifies the following indications for its use: "(*a*) When the exit of the chyme from the stomach is hindered by a mechanical obstruction giving rise to decomposition, as in most forms of dilatation of the stomach; (*b*) where foreign or irritating collections are mixed with the gastric contents which sooner or later interfere with digestion. These may be of mucus or bile or abnormally increased gastric juice." For these purposes he uses warm alkaline and saline solutions, and subsequently solutions of bismuth or silver nitrate. Careful details for carrying out this mode of treatment, the introduction of the tube, etc., may be found in Hemmeter's treatise or in Foster's "Reference Book of Practical Therapeutics," *sub verbo*. In the treatment of acute indigestion lavage is often to be preferred to the administration of an emetic. The *stomach douche* is a more recent addition to the armamentum medicum of the same class.

Disinfectants include drugs of which the following are among those best known and which have been found most efficacious, viz.: Naphthalene, the sulpho-carbolates, the salts of bismuth, carbon finely divided, salol and its congeners, and probably the bichloride of mercury. They are believed to prevent putrefaction and abnormal fermentative processes in the contents of the bowels. As a result they often relieve pain, check diarrhœa, and prevent such auto-intoxication as may lead to irregular and persistent fever and to acute rheumatic affections of the joints. Salol, creosotal, and their kind have the recommendation that they pass through the stomach unchanged, to be dissolved only by the intestinal secretions, where they become active. The search for the ideal disinfectant for internal administration has not yet been crowned with success, owing to the difficulty of finding a drug which is sufficiently soluble and which will retain its disinfectant properties after meeting the intestinal fluids and yet not develop irritating or poisonous properties.

The Digestive Ferments are interesting physiologically as well as therapeutically, though when we confine ourselves to "remedies that aid digestion" there are but few of them that come within our purview. Thus the saliva contains an enzyme, *ptyalin*, the function of which is to change starch to sugar and to the products intermediate between starch and sugar. Its direct bearing upon our subject is to show the importance of *mastication* in salivary digestion, for it breaks open the starch-cellulose envelopes and thus exposes a larger surface to the action of the enzyme; but ptyalin itself is little used as a medicinal remedy. The most important of the amylolytic or starch-digesting class is *diastase*, which is obtained from germinating grain, and is familiar under the names of malt extract, Maltine, or Maltzyme, and with it belongs *taka diastase*, which is obtained from a fungus called Eurotium oryzæ, and is much more powerful than the malt extracts. Like the other digestive ferments diastase is much used to strengthen the weakened digestive secretions, but its province is less well defined than in the case of some others, for the existence of a condition deserving the name of "amylaceous dyspepsia" is certainly questionable. According to Osler, "Ptyalin and diastase are particularly indicated when the acid is excessive, and the malt diastase is often very serviceable when given with alkalies." Many of the preparations of malt diastase contain some percentage of alcohol, making them equivalent to a mild stout or beer (Cushny). Coming now to the proteolytic digestive ferments the most familiar one is *pepsin*. This is usually obtained from the stomach of the pig. It acts in an acid solution only, preferably one containing 0.2 per cent. of hydrochloric acid, which is nearly the same as the proportion of that acid in the gastric juice. Ewald is quoted to the effect that "the use of pepsin may be limited to the cases of advanced mucous catarrh and the instances of atrophy of the stomach." It has, however, been largely used with the view of reinforcing the digestive capacity of the stomach for proteids in other conditions, and doubtless its administration has often been superfluous, for it is found that "the gastric juice is almost always capable of digesting proteids if it is acid in reaction" (Cushny). Pepsin is best administered in powder or in solution with acid. *Pancreatin* is an extract of the pancreatic gland of the pig and should represent the various enzymes found in the pancreatic juice. These are *amylopsin*, which is amylolytic; *trypsin*, proteolytic, but requires an alkaline medium for its action; *steapsin*, which causes emulsification of fats in the alkaline solution (Hall). It is thus apparent that an efficient digestive aid can be expected from this preparation only when it can be brought to act upon the intestinal contents where their reaction is alkaline. It is therefore customary to combine it in tablets with bicarbonate of soda, to neutralize the destructive acidity of the gastric juice, or to enclose the drug in a coating of keratin to protect it from the gastric juice while passing through the stomach. Among the proteolytic ferments should also be mentioned *papain* or *papoid*, derived from the carica papaya or pawpaw. It is used to some extent as a substitute for pepsin or pancreatin, but has the peculiarity of acting either in warm or cold, in moderately acid, alkaline, or neutral solutions.

Upon milk it exerts the double action of curdling and then peptonizing. In this connection the following quotation from Hemmeter may not be inappropriate. "Predigested foods, such as somatose, Mosquera's beef meat and such others as are tasteless, when mixed with food so as not to be detected, are useful when the digestion of albumen in the food becomes insufficient, or when as in some cases of carcinoma or tuberculosis there is inadequate absorption of nitrogenous food."

The indication for *alkalies* as digestants is the presence or secretion of an excess of hydrochloric acid in the stomach. For this purpose they are used as ingredients of the fluid of lavage, as well as to liquefy tenacious mucus. While there is no doubt of the value of alkalies given half an hour to an hour after meals in cases of excessive acidity, on the other hand the most contradictory views are held by good authors as to the result upon the secretion of acid from giving alkalies before eating. Magnesia, carbonate of magnesia, and lime are commonly classed as *antacids*. They also are used in excessive acidity of the stomach and in acid putrefaction in the bowels, and it is believed that the magnesia salts produced in the intestinal canal under these conditions are less irritating than the lime salts and may have the additional advantage of acting as mild purgatives. Of *acids* by far the most important as an aid to digestion is *hydrochloric*, as the ingredient in which the gastric juice is most often lacking. *Nitric* acid is also used by itself and in combination with hydrochloric, and so is to some extent *phosphoric* acid. A consideration of the physiology of stomach digestion as already referred to in this article furnishes the explanation of their use. They are often given with the bitters, as strychnine or gentian, with pepsin and with carminatives such as cardamom, one enhancing the effect of the other in the combination. Dilute hydrochloric acid may be given in doses of ♏xv. to xx. after eating, although as much as a drachm or a drachm and a half has been recommended by some of the best authorities.

Availing ourselves of the anæsthetic action of *cocaine*, we may sometimes employ that drug to check vomiting when threatened in irritation of the stomach. *Arsenic* has a specific action in causing fatty degeneration of the epithelium of the stomach and intestines, and the effects attributed to it of increasing appetite and promoting digestion may perhaps be due to a mild degree of the same action on the epithelium (Cushny). Be that as it may, we often see nutrition improve under the use of the drug, especially when given with iron. The sedative action of the *bromides* is also made use of to diminish the irritability of the stomach which prevents the retention of an adequate quantity of food. *J. Haven Emerson.*

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DIGESTION.—The purpose of digestion is to prepare the food for absorption and assimilation, so that it may form a suitable nutriment for the tissues of the body.

During the process of digestion the food lies within the alimentary canal, along which it is gradually moved by appropriate contractions of the muscular walls.

Here the food-stuffs, through the agency of the digestive juices, undergo chemical and physical modifications which render the various constituents in the end more soluble and capable of easy absorption by the columnar cells of the intestine.

A complete account of digestion would accordingly deal with the movements of the various parts of the alimentary canal and with the mode of secretion and chemical properties of the digestive fluids, in addition to describing the action of these digestive secretions upon the food-stuffs.

It is, however, more appropriate, for facility of reference, to treat of the mechanics of digestion under the various headings of mastication, deglutition, intestinal movements, and defecation; while the properties of the various digestive juices will be found under their names and those of the ferments which they contain.

In this article we shall, therefore, chiefly consider the action of the digestive juices upon the food in the different parts of the alimentary canal.

Buccal Digestion.—The chief function of the saliva undoubtedly is that of facilitating the swallowing of solid food. This is shown by the fact that *mucin*, the most important of the organic constituents and one which is invariably present, has no chemical action whatever on any of the food-stuffs. On the other hand, *ptyalin*, which is the only chemically active substance, is absent in certain classes of animals, such as all the typical carnivora. The water of the saliva, which is intimately mixed with the food in the process of mastication, makes the mass of much softer consistence, while the mucin at the same time coats it over with a slippery envelope, so that the subsequent passage along the œsophagus is for both these reasons rendered easier.

The more important effects exerted upon the food in the mouth are hence physical in character, viz., a comminution by the teeth, a softening by imbibition and mixing with the water of the food, and a slippery surface conferred by the mucin of the saliva. In addition to these, however, a chemical action is initiated in man and most mammals upon any starches present in the food, which is of some importance because of the rapidity of the action, and of the fact that the activity is continued for a considerable time after the food passes into the stomach.

This action on the starches is due to a diastatic enzyme, which has been named *ptyalin;* although like all other enzymes it has not yet been isolated as a chemical individual. The chemical action is typical of that of the entire class of diastatic enzymes, such as malt diastase or amylopsin of the pancreatic juice, and hence merits a short description.

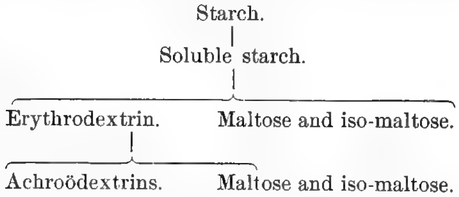
In the reaction, the ptyalin is not itself chemically involved, but it sets up a catalytic change in which the elements of water are taken up by the complex starch molecule, which at the same time becomes resolved into simpler bodies. The first evidence of this *hydrolysis* and accompanying degradation of the starch molecule is physical in character and consists in the formation of soluble starch, or *amidulin*. Starch paste to which saliva has been added loses at this stage its viscid character, the common property of colloidal solutions containing giant molecules, and becomes limpid and more like a true solution. The solution still retains, however, the chemical properties of starch, as is shown by its giving the usual deep blue coloration on the addition of iodine. This first stage of the action of ptyalin upon starch takes place very rapidly, especially when the starch granules have been burst by previous cooking, as short a time as thirty seconds being sufficient to render a stiff starch paste completely fluid, when a few drops of saliva are added at body temperature. This first action is hence of considerable importance, for under proper conditions of mastication practically all the boiled starch of the food ought to enter the stomach as *soluble starch*. When the starch has not been previously boiled the action is infinitely slower, since there is a thin membrane of *starch cellulose* surrounding each starch granule, and this membrane retards the action of the ptyalin upon the enclosed *starch granulose*.

The further stages in the action of ptyalin upon starch consist in a gradual advance of the process of hydrolysis. As a result there is formed a variable mixture of maltose and iso-maltose, with dextrins, of which the constituent individuals have never been satisfactorily isolated. The hydrolysis never becomes complete no matter how prolonged be the interval of time allowed. There is indeed no complete conversion of dextrins into sugars, not even when the dextrins finally formed are precipitated from solution and treated anew in fresh solution with saliva.

The blue coloration with iodine ceases to be obtainable when the starch has all been converted, and is replaced by a red color which is said to be given by a hypothetical substance, called from the red color, *erythrodextrin*, although no chemical substance corresponding to this name has ever been isolated. At a later stage no coloration is obtained with iodine, and for this reason the dextrins then in solution are spoken of as *achroödextrins.* There are probably several dextrins at this final stage, as is indicated by the fact that fractional precipitation with alcohol yields products of varying rotatory power for polarized light. No sufficient isolation of these bodies has yet been accomplished, although the names of α, β, and γ achroödextrin have been applied to products of different physical properties obtained from the mixture.

The sugars formed are maltose and a closely allied sugar named iso-maltose; inversion of these disaccharides into monosaccharides by ptyalin does not take place to any appreciable extent, but various observers describe the presence of a *small* percentage of dextrose.

From the fact that maltose appears early in the process of hydrolysis, even at the stage of erythrodextrin, and increases in amount as achroödextrin is formed, it has been concluded that a certain percentage of maltose is formed early in the decomposition of the starch molecule, and the process is hence usually represented schematically thus:



There is, however, as has been pointed out by Lintner and Dull,* no logical basis for such an assumption, for in such a chemical reaction, of considerable time duration, there is absolutely no reason to believe that the starch molecules are all attacked at the same rate by the ferment and at any given moment are all equally advanced in hydrolytic cleavage. There is no reason why the maltose simultaneously present with the erythrodextrin should not be the product of more advanced hydrolysis of other starch molecules, rather than split off in the formation of erythrodextrin in the beginning. It is in fact more probable that there is formed a series of more and more simple dextrins which give rise in the end to the disaccharides, than that such simple molecules should be split off in the early stages of cleavage as congeners to much more complex bodies.

No particular effect is exerted on proteids and fats in the mouth, since the saliva contains no ferments which act upon either of these classes of food-stuffs.

Gastric Digestion.—The primary office of the stomach, and that which undoubtedly led to the development of that organ, is to afford storage for the food until it can be taken up for digestion and absorption by the intestine. That fraction of the food taken in at a full meal which is capable of being accommodated and acted upon in the intestine is a small one; the chief part of the meal must accordingly be temporarily stored in some receptacle and passed on through the pylorus from time to time as intestinal digestion and absorption proceed. This important use of the stomach is illustrated by the fact that the stomach can be completely removed in the dog, provided the animal when it has recovered from the operation be frequently fed with very small portions of food. At first only a very little food at a time can be retained, and the animal requires to eat almost continuously, but after a time a distention forms in the alimentary canal at the former situation of the stomach, and the animal can retain a meal for almost as long a time as before the operation. The stomach has also been practically completely removed in man, as a consequence of malignant disease, with similar results. By these cases it is demonstrated that the chemical activity of the stomach is not essential to digestion; while the tendency to the formation of a distended portion and the fact that small quantities of food can only be borne at first after complete gastrectomy indicate the primary use of the stomach as a storehouse for the food after a meal.

As soon as the food passes the cardiac orifice the sphincter closes, and as the pyloric sphincter is also normally closed, the stomach thus forms during the greater part of the time a closed sac which is completely occluded from the remainder of the alimentary canal. In this receptacle the food is churned about by very active contractions of the muscular coats, which movements serve to intimately mix the food into a more or less homogeneous, semifluid mass.

The mixed mass produced by this churning action is termed *chyme.* Its character, both in physical appearance and chemical composition, naturally varies widely with the extent of previous mastication and the nature of the food, and hence the usual description of a semifluid mass of the consistence and appearance of pea soup is often very wide of the mark. (See article on *Chyme.*)

From time to time, and always at the close of a contraction of the muscular coats, a portion of the chyme is passed into the duodenum by a temporary relaxation of the pyloric sphincter. The rate of passage of food from the stomach to the duodenum is regulated reflexly, and the afferent impulses appear to be controlled by the condition of the intestine as regards the presence of food undergoing digestion.

Thus, a primary function of the stomach is to act as a normally closed temporary reservoir for the food, from which it is doled out into the intestine as the progress of intestinal digestion and absorption warrants. Other functions than this have, however, developed in connection with the stomach, and these may be briefly enumerated as follows:

1. The hydrochloric acid of the gastric juice neutralizes the alkali of the saliva, and in the end the chyme acquires a strongly acid reaction. As a result of this the conversion of starch into sugars and dextrin, as described above, is brought to a standstill by the complete destruction of the ptyalin.
2. The hydrochloric acid acts at body temperature as a strong inverting agent, thus changing practically the whole of any cane sugar which may be present into invert sugar, *i.e.*, a mixture in equal proportions of dextrose and lævulose.
3. The hydrochloric acid acts as a powerful disinfectant, arresting putrefaction if that has already commenced in the proteid food, preventing or minimizing acetic or lactic fermentation of carbohydrates, and destroying many pathogenic bacteria or their spores, thus reducing the danger of infection of the intestine and hence of the organism as a whole by many classes of bacteria.
4. The pepsin (*q. v.*) of the gastric juice has a powerful digestive action upon all forms of proteid.
5. The rennin, or milk-curdling ferment, also present, influences specially the digestion of milk by previously coagulating it; as a result it is retained for a longer period in the stomach and intestine and hence undergoes a more complete digestion.

The exact period of time after a meal at which the reaction of the chyme changes to acid, has been the subject of much debate. It is probably a very variable period,—one that alters with the character of a meal, the amount of mastication and accompanying insalivation, and the vigor of secretion of the hydrochloric acid of the gastric juice. A meal rich in carbohydrate increases the length of this period, and one rich in flesh meat diminishes it. As an average the time until free hydrochloric acid is present may be placed at from twenty minutes to half an hour. During this period conversion of starches into dextrins and sugars proceeds with unabated rapidity, for ptyalin is still more active in a neutral or nearly neutral reaction than in a strongly alkaline one. As soon as any free hydrochloric acid is present the ptyalin is rapidly destroyed.

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* Quoted by Neumeister, Physiol. Chemie, 2te Auflage, 1897, S. 287. (Lintner and Dull., Ber. d. deutschen chem. Gesellsch., Bd. xxvi., 1893, S. 2539.)

It is not improbable, however, that a certain amount of conversion of starch goes on by means of the hydrochloric acid, for, after feeding dogs on starch, a considerable amount of maltose and dextrin is found in the stomach contents, although dog's saliva contains no ptyalin. This subject still requires investigation.

The inversion of cane sugar proceeds much more slowly in the presence of the products of proteid digestion, and if all the acid present be combined with such products it comes practically to a standstill. In the absence of proteid products the inversion proceeds so rapidly as to render it probable that almost complete inversion takes place during the stay of food in the stomach (Lusk).

It has been stated by various authors that a very considerable conversion of neutral fats into free fatty acids and glycerin takes place in the stomach. Experiments by the writer have given the result that practically no such hydrolysis takes place at the temperature of the body, under the action of pure solutions of hydrochloric acid alone of a strength comparable to that of the gastric juice. Since the gastric juice contains no fat-splitting ferment it is indeed difficult to understand the above-mentioned experimental results.

The important use of the hydrochloric acid as a disinfectant is illustrated by the evils attendant upon subacidity of the stomach, or still more by entire absence of hydrochloric acid secretion. Under these conditions the interrupted gastric digestion of proteids produces far less baneful effects than does the infection of the stomach by bacteria, which flourish upon the carbohydrate food, setting free gas which causes distention of the stomach and intestine, and also free organic acids such as acetic, lactic, and butyric, which vitiate intestinal digestion and set up chronic gastric and intestinal catarrh. The value of hydrochloric acid as a germicide is also considerable; and undoubtedly sub-normal acidity is a powerful predisposing cause to those diseases in which the intestine becomes a prey to specific bacterial infection, such as typhoid and cholera. It has been shown that certain spores are more resistant to the action of the gastric hydrochloric acid than are the bacteria themselves; this has been found, for example, in the cases of the spores of cholera and anthrax.

The first stage in the action of pepsin upon proteid is the formation of acid albumin; the proteid being dissolved during this first stage if it is not initially in a state of solution. Since acid is present it might be supposed that in this stage the pepsin takes no part, and that the action is a conversion of native proteid into acid albumin by the hydrochloric acid alone acting at body temperature. This, however, is not the case, for although pepsin is inactive in the absence of the acid, the latter merely confers a favorable medium upon the pepsin which then acts upon the proteid and causes or at least initiates the transformation. This is shown experimentally by the fact that a coagulated proteid, such as fibrin, is only infinitely slowly converted into acid albumin at body temperature by hydrochloric acid alone when it is of the same degree of concentration as the gastric juice, whereas on the addition of pepsin the transformation is a rapid one. It is possible that the change to acid albumin takes place in two stages, viz.: first, an action of the pepsin upon the proteid, giving a soluble modified proteid; and, secondly, a conversion of the product of this first action into acid albumin by the acid as it is formed in the nascent condition in the presence of the acid. This view is rendered probable by the fact that in the action of trypsin upon proteid which takes place in an alkaline medium, alkali albumin is similarly formed; and the fact indicates, further, that most probably the proteid is subjected to an initial modification by the action of the trypsin, which is acted upon as it is formed by the alkali present and converted into alkali albumin.

The stage of formation of acid albumin can be demonstrated just as the proteid has disappeared into solution, or at any time before this stage, by filtering and neutralizing, when a precipitate is obtained. With a very active pepsin solution, the amount of acid albumin so precipitable at any period is very small, for the acid albumin is attacked further by the pepsin and hydrochloric acid, and changed into albumoses which are not precipitable on neutralization. With weaker solutions of pepsin also, after all the proteid has passed into solution, the amount of acid albumin, as demonstrated by the amount of neutralization precipitate, gradually diminishes, and, if the pepsin solution has not been too weak, finally disappears. If, however, the pepsin solution is very weak, the action becomes identical with that of very dilute acids acting alone for a prolonged time, and there is produced a very stable form of acid albumin which undergoes no futher change. In the normal action of pepsin and hydrochloric acid this does not take place and all the acid albumin first formed is afterward changed into albumoses. This change takes place by action upon the portions of acid albumin first formed, simultaneously with the production of further acid albumin, so that, even before complete solution has taken place, both acid albumin and albumoses are present together in solution.

The albumoses are formed, according to Neumeister, in two successive stages: first, proto- and hetero-albumose are formed, and accordingly these are termed primary albumoses; at a later stage these become converted into deutero-albumoses, which are therefore called secondary albumoses. The primary albumoses are precipitated from solution on saturation with sodium chloride; to precipitate the deutero-albumoses a further addition of acetic acid is required.

Finally, a certain percentage of deutero-albumose becomes changed into peptone, which is distinguished by not being precipitated on complete saturation with ammonium sulphate.

The process, like the action (described above) of ptyalin upon the starches, never becomes complete, but the final result is always a mixture of albumose and peptone which cannot be further peptonized by pepsin. The albumoses, in so far as they are not absorbed as such, are, however, converted into peptones and amido-acids by the trypsin of the pancreatic juice in the course of intestinal digestion.

There is a considerable variation in the length of time occupied by the stomach, after a meal, in discharging its contents, the period varying with the character of the meal, the previous state of nutrition, and most of all with the character of the animal. In herbivora, for example, the stomach, except in very prolonged inanition, is never empty of food, while in a carnivorous animal (especially after a previous period of starvation) the stomach may be found empty one or two hours after a meal. A fatty meal is retained longest in the stomach; a light meal, such as bread or rice, passes on to the intestine rapidly; while lean meat remains in the stomach for a period of time intermediate between these two. The mean period in man may be approximately stated at from four to six hours. A distended or relaxed condition of the stomach increases the interval, and under pathological conditions the stomach may never become completely cleared of food. Diminished acidity of the gastric mucous membrane also tends to increase the period of gastric digestion.

Intestinal Digestion.—The chyme, as it is passed out at intervals through the pylorus into the duodenum, has always under normal conditions a strongly acid reaction, due to hydrochloric acid, but becomes at once immersed in a strongly alkaline bath which has been prepared for it in advance by the secretion into the duodenum of bile, pancreatic juice, and *succus entericus.* As a result of this the free hydrochloric acid is almost at once neutralized, and usually the intestinal chyme acquires an alkaline reaction to all stable indicators within an inch or two of the pylorus.

The older view that an acid reaction due to hydrochloric acid persists for some distance down the small intestine, and that the acid is only gradually neutralized, is, according to the experience of the writer, erroneous and founded on a misconception—viz., that a considerable amount of chyme is expelled at once from the stomach and is gradually mixed with the alkaline secretions as these are secreted, so that in the end the hydrochloric acid is neutralized. As a matter of fact, the amount discharged at any one opening of the pylorus is small, and the mass is shot out, not into an empty duodenum, but into one charged already with alkaline secretion. In a large number of experiments in which free hydrochloric or strong organic acids such as acetic or lactic were tested for by methyl orange, I have scarcely ever obtained an acid reaction, even within two inches of the pylorus, either in carnivora or in herbivora.

It is interesting to observe the economy of the digestive enzymes of the pancreatic secretion which is attained by such an arrangement of previous secretion into the duodenum of alkaline fluids and the discharge of the acid gastric chyme into a quantity of such secretion. On the old view, since all three pancreatic enzymes are extremely susceptible to mere traces of free hydrochloric acid and are almost instantly destroyed thereby, all the pancreatic juice secreted for the considerable period of time which elapses until the hydrochloric acid has been neutralized would be destroyed. In fact, nearly all the pancreatic activity would be thus removed, for this secretion is poured only into the duodenum, and according to the older views, the acidity persists beyond this portion of the intestine. On the view that the chyme is discharged into an alkaline bath and almost instantly neutralized, practically no such destruction would occur.

According to other authors, who admit that the hydrochloric acid is rapidly neutralized, there is, nevertheless, no alkaline reaction in the small intestine; but, on the other hand, there is a markedly acid reaction due chiefly to acetic acid set free by the energetic action of bacteria upon carbohydrates. This acidity is further said to increase in degree as the intestine is descended even until the ileo-cæcal valve is reached. This view is supported chiefly by a few observations upon clinical cases of fistulæ near the ileo-cæcal valve.

In a large number of experiments upon various classes of animals, I have never found an acid reaction due to any stronger acids than those of the fats of the foods. After a fatty meal, and in the carnivora only, a faintly acid reaction to litmus is obtained; this is, however, due to the weak organic acids set free from the fats by the hydrolytic action of the steapsin, as is shown by the fact that no acid reaction, but instead a strongly alkaline one, is obtained with methyl orange. This acid reaction is too weak to effect the activity of any of the intestinal enzymes, and usually persists for from one-third to one-half the length of the intestine. An acid reaction due to acetic and lactic acids was obtained in one case only, but here the small intestine was also distended with gas, and digestion was obviously not proceeding in a normal fashion. From these experiments it is obvious that in animals of widely different species, and therefore most probably in man also, there is no appreciable destruction or digestion of carbohydrates in the small intestine by the agency of bacteria. Since in a mixed food carbohydrates are attacked before proteids, it is probable that bacterial action upon the mixed food in the intestine is inconsiderable in amount. The degree of alkalinity varies with the food, being greatest on carbohydrates and least on fatty food.

The chief digestive secretions which affect the food in the intestine are the pancreatic juice and the bile, the succus entericus possessing, so far as we know, but a subordinate value as an aid to digestion.

The pancreatic juice contains three important enzymes, each of which has a digestive action upon a different one of the three great classes of food-stuffs; as a result, all the important elements of the food are attacked in the small intestine by the pancreatic juice. Thus, carbohydrates are subjected to the action of the diastatic enzyme, amylopsin; fats are hydrolyzed by the steatolytic enzyme, steapsin; while proteids are peptonized by the proteolytic enzyme, trypsin.

The action of amylopsin resembles in every respect that already described in the case of ptyalin. So close is the resemblance that certain writers state that the two ferments are identical; of this, however, there is no experimental evidence, since neither body has been isolated. Pancreatic juice acts more energetically than saliva upon starches, but this may merely mean a difference of concentration.

Pancreatic juice contains, so far as is at present known, the only enzyme possessing a specific chemical action upon the neutral fats. This action consists in decomposing the fats into free fatty acids and glycerin. Until quite recently it was held that only a small percentage of fat underwent this change, and that the fatty acids so set free combined with the alkali of the intestinal contents to form soaps. In the process of combination it was supposed that the soaps converted the remaining larger portion of undecomposed fat into a fine emulsion which was then absorbed in this chemically unaltered form by the columnar cells.

Recent experimental observations have tended to invalidate this emulsion theory of absorption, and it is now held by many that all the fat of the food is absorbed in soluble form. The chief facts in favor of this view may be summarized as follows:

1. The rapidity of action of steapsin is such as to admit of the saponification of all the fat of a full fatty meal within the ordinary period of digestion.
2. It has never been shown by histological examination that fat particles pass into the columnar cell; on the contrary, the broad striated border of the cell is invariably free from fat granules.
3. Examination of the columnar cells at varying periods after a fatty meal shows that the fat globules seen in these cells continuously grow larger as the period of absorption increases, indicating that the globules are deposited from solution.
4. Although fatty acids are insoluble in water they are fairly easily soluble in bile solutions and exist in solution in the intestinal contents of some classes of animals during fat digestion. The solubility of the different soaps is also greatly increased by the presence of bile in the intestinal contents, and soaps are also found in the intestinal contents during fat digestion.

It is probable from these various observations that the entire fat of the food is hydrolyzed in the intestine to fatty acids and glycerin, that the fatty acids are entirely or in part neutralized to soaps of the alkaline metals by the alkali of the intestinal contents, and that these soaps, or the mixture of soaps and free fatty acids, are absorbed in solution by the columnar cells.

In the columnar cells the constituents of the fats are recombined to form neutral fats, and here it is interesting to note that the columnar cells appear to be capable of furnishing glycerin for the synthesis to neutral fat, for even when free fatty acids are fed, only neutral fats are to be found thereafter in the thoracic duct.

It has been stated above that the action of pepsin upon proteid never amounts to complete peptonization; in addition to this a considerable amount of proteid matter passes through the pylorus which has not been chemically altered at all by the gastric juice. An examination of the contents of the upper part of the small intestine, after a meal containing flesh, usually demonstrates undigested fragments and often pieces of considerable size floating in the thin fluid contents of the intestine. Such macroscopic fragments become less frequent and smaller as the intestine is descended, evidently because of advancing solution, while at the same time the fluid portion becomes thicker, so giving rise to a more homogeneous mass of ever-increasing thickness as the ileo-cæcal valve is approached. The action of trypsin upon proteids is both more complete and more rapid than that of pepsin. The preliminary stages are rushed through more rapidly. The first stage, as mentioned above, is that of alkali albumin, but this substance is rapidly converted into deutero-albumose, this in turn into peptone, and the peptone in great part into amido-acids and organic nitrogenous bases. It is doubtful whether any primary albumoses are formed in the course of tryptic digestion; if they are, the stage is an exceedingly unstable one and they are quickly changed into deutero-albumoses. The deutero-albumoses are easily demonstrated in the earlier stages of tryptic digestion, but are converted later into peptone. The conversion of peptone into simpler bodies proceeds more slowly, and only about half the peptone gets so completely decomposed as not to give most of the reactions of the proteids. The more stable portion is usually termed *antipeptone*, but it is unknown whether this term represents a complex of various bodies or a single chemical substance. Recent experiments have tended to show that it is a mixture of several substances of much simpler constitution than anything deserving the name of proteid or peptone.

The above description applies to the complete process of tryptic digestion of proteid, but the partially digested proteid resulting from previous peptic digestion, in so far as it has not been previously absorbed, undergoes the later stages of tryptic digestion.

We have at present no means of knowing what fractions of the proteid are absorbed in the various intermediate forms, but we do know that even native proteid is capable of absorption from the intestine, and that digestion merely serves to increase the ease of absorption. It has been shown that the rate of absorption is greater for alkali albumin than for albumins or globulins, and that there is a still greater increase for albumoses and peptones. It is hence probable that a certain fraction of proteid is absorbed as alkali albumin and a still greater portion as albumose, and it is exceedingly unlikely, except when the proteid consumption is largely in excess of the demands of the animal, that any considerable amount passes the stage of peptone. Such a deep-seated chemical change would mean a useless expenditure of energy intended for the tissues in the intestine, where it could merely directly increase the heat production of the animal.

It is similarly probable that a certain amount of the carbohydrate food is absorbed as dextrins, although no dextrin is to be found in the blood of the portal vein. Röhmann finds that even starch disappears from a Thiry-Vella fistula with considerable rapidity, and, since the succus entericus possesses no diastatic action, this must be taken as indicating that the columnar cells are capable of taking up starch molecules. In the entire absence of the pancreatic secretion, also, from one-half to three-fourths of the starch ingested has been found to disappear (Minkowski and Abelmann). Under normal conditions it is, however, probable that practically all the starch of the food is converted into a mixture of dextrin and maltose before absorption.

The only ferment contained in the *succus entericus* is one which has an inverting action upon cane sugar and maltose, and has accordingly been termed *invertin*. This enzyme has a rapid action upon cane sugar and maltose, but is stated to be without action upon lactose. The latter sugar is therefore in all probability absorbed as such, except in so far as it is hydrolyzed in the stomach.

The bile contains no enzymes which possess a chemical action upon any of the food-stuffs. It has recently been shown by the writer that the most important uses of the bile lie in its properties as a solvent for certain substances which are insoluble in water. In this capacity it acts as an excretory agent by dissolving lecithin and cholesterin, both of which are completely insoluble in water; thus rendering possible the removal of these waste products, chiefly of the metabolism of the nervous tissues from the body. Further, the bile, as has been pointed out above, acts as a powerful ally to the pancreatic juice in fat absorption by conferring increased solubility upon the soaps and rendering soluble the free fatty acids.

These solvent properties of the bile depend chiefly upon the bile salts; the practical service of which to the economy is shown by their complete absorption, constituting the so-called circulation of the bile. All the other biliary constituents—except lecithin, which is decomposed and in part reabsorbed in altered condition—are excretory in character and are thrown out in the fæces.

It is noteworthy, in view of the fact that human biliary calculi consist chiefly of cholesterin, that this substance, which is *quite* insoluble in water, only possesses a feeble solubility in solutions of bile salts, amounting to from one- to two-tenths per cent.; it is, therefore, that constituent of the bile which is most likely to be thrown out of solution by any circumstance which either increases the amount of cholesterin to be excreted by the liver, or diminishes the solvent power of the bile, such as a diminution of bile salts. Lecithin is much more soluble and hence is never found in biliary calculi. A five-per-cent. solution of bile salts at body temperature is capable of taking up as much as seven per cent. of lecithin.

The reabsorption of bile salts is practically complete at the ileo-cæcal valve, as is shown by the fact that the reaction from Pettenkofer's test cannot be obtained with the intestinal contents as they escape from a fistula of the small intestine situated immediately above the ileo-cæcal valve.

The fate of the intestinal enzymes during the process of digestion has been much debated. It is certain that ptyalin is completely destroyed by the hydrochloric acid of the gastric juice, and pepsin in turn by the alkali of the intestine; but much doubt exists as to the fate of trypsin, amylopsin, and steapsin. It has been known for some time that the blood plasma possesses feeble amylolytic and proteolytic powers, and it has been inferred that these properties were due to absorption of the ferments from the intestine. It has, however, been shown that the blood plasma is richest in these traces of enzymes during inanition and poorest in them during the period of digestion, which would indicate that the enzymes are taken up by the blood from the cells of the overcharged digestive glands and not absorbed during digestion from the intestine. It is quite certain that all the digestive enzymes are not absorbed before the large intestine is reached, because the contents of the small intestine escaping from a fistula immediately above the ileo-cæcal valve are very rich in both amylolytic and proteolytic ferments, as is shown by their rapid digestive action on both starch and fibrin. Further, it is from the economic point of view exceedingly undesirable that the enzymes should be absorbed by the columnar cells, since they would then, by their activity, interfere with the reverse processes of synthesis of digestion products which goes on in the cell. Hence it is highly probable that the process of selective absorption which reaches its acme in the columnar cells, has so developed in them as entirely to prevent the absorption of these enzymes, which in all probability undergo decomposition in the large intestine.

The absorption of the soluble portions of the food, except in herbivora, is practically completed under normal conditions in the small intestine, for the intestinal contents at the level of the ileo-cæcal valve usually contain neither soluble proteid nor carbohydrate.

In the upper part of the small intestine the secretion of water into the intestine by the digestive glands more than counterbalances the absorption of water by the columnar cells, so that the intestinal contents are fluid, mixed with lumps of undigested food. In the lower third, the absorption of water outbalances secretion so that the contents become thicker, and at the ileo-cæcal valve they usually constitute a thin, semi-solid mass. In the large intestine, the absorption of water still proceeds and the contents gradually take on the consistence of fæces. The degree of dryness of the fæces varies chiefly with the rapidity with which they pass through the large intestine and the avidity of its mucous membrane for the water contained therein. In addition to this continued absorption of water, the chief changes in the contents of the large intestine are due to bacterial action. In the large intestine bacteria flourish abundantly. The ileo-cæcal valve possesses a peculiar function as a barrier against bacteria, the modus operandi of which is entirely unknown to us. As an experimental fact it is well known, however, that the large intestine swarms with bacteria, while they are absent on the upper surface of the ileo-cæcal value. The proteid matter is attacked below the valve by putrefactive bacteria; these set free those volatile bodies which give the fæcal odor to the contents, and they also form stable organic sulphates, which are absorbed and excreted practically unchanged in the urine. Cellulose and other insoluble forms of carbohydrate are also attacked here by bacteria, giving rise to marsh gas and hydrogen which escape by the rectum.

The fæces constitute a very complex residue, which consists in part of undigested débris of food, such as shreds of cellulose, connective tissue, and elastic tissue, and, when the food has been excessive or mastication imperfect, there will be lumps of unattacked food which have escaped the digestive action of the secretions. In addition to this there is a considerable amount of matter not derived from the food, such as detritus from the columnar epithelium, mucin secreted from the intestine, and excretory matter from the bile. The color of the fæces varies greatly and is derived from many sources; it changes with the character of the food, being black or brown, in the case of a flesh diet, from sulphide of iron formed from the hæmoglobin by reduction in the intestine, and light yellow in color, in the case of a vegetable diet, in which the color is due chiefly to bile pigments

The gases of the intestine indicate that strongly marked reduction processes go on therein; thus, for example, oxygen is entirely absent, and the usual gases are marsh gas, hydrogen, and sulphureted hydrogen. The reducing processes going on are further evidenced by the formation of suphide of iron, as mentioned above, and by the reduction of the bile pigments to hydrobilirubin.

Benjamin Moore.

DIGESTION, DISORDERS OF. See *Stomach, Diseases of,* and *Enteritis.*

DIGITALIS.—FOXGLOVE. The leaves of *Digitalis purpurea* L. (fam. *Scrophulariaceæ*) collected from plants of the second year's growth" (U. S. P.). The British Pharmacopœia specifies "from plants beginning to flower." The German Pharmacopœia requires them to be collected from wild plants in bloom. Other definitions have specified "in full bloom" or even the entire herb in some specified stage of maturity. At present, all these definitions agree in the one important point that the leaves only are employed, the constituents of the flowers and seeds differing in character and properties, and being thus properly excluded. They all agree, moreover, in requiring leaves of the second year's growth, inasmuch as the plant does not flower during the first year. All things considered, the specification of the flowering stage as the time for collection is wise, as the allowance of a very much earlier or very much later period gives no guarantee of the desired quality. There is also little doubt that the wild-grown leaves are usually more active than those of cultivation, though the difference is commonly overestimated.

The plant is very abundant, except in the coldest parts, throughout Europe, besides which it is largely cultivated. It reaches its greatest physical perfection in our northwestern coast States, where it is extensively naturalized along roadsides, attaining a height of ten and even twelve feet. Ordinarily it reaches a height of from two and one-half to four feet, one or more usually simple, erect stems arising from a rosette of radical leaves which replace a similar rosette produced, with the stout conical or fusiform root, during the first year. Upon the stems, the leaves become smaller toward the top, and are finally reduced to large floral bracts. The handsome, drooping, bell-shaped, purple flowers, spotted within with darker purple, are racemed along one side of their stems, generally for more than half their length.

The drug usually comes in bales, sometimes pressed into hard cakes or blocks of different sizes. Some very finely selected leaves are powdered abroad and are imported in small expensive packages, specially for administration in powdered form. The drug is thus described by the Pharmacopœia:

From 10 to 30 cm. long; ovate or ovate-oblong, narrowed into a petiole; crenate; dull green, densely and finely pubescent; wrinkled above; paler and reticulate beneath; midrib near the base broad; odor slight, somewhat tea-like; taste bitter, nauseous.

An infusion prepared with 1 part of digitalis and 10 parts of boiling water, and allowed to cool, has a peculiar odor, turns blue litmus paper red, and, upon the addition of a few drops of ferric chloride T. S., acquires a darker tint, a brown precipitate appearing after a few hours.

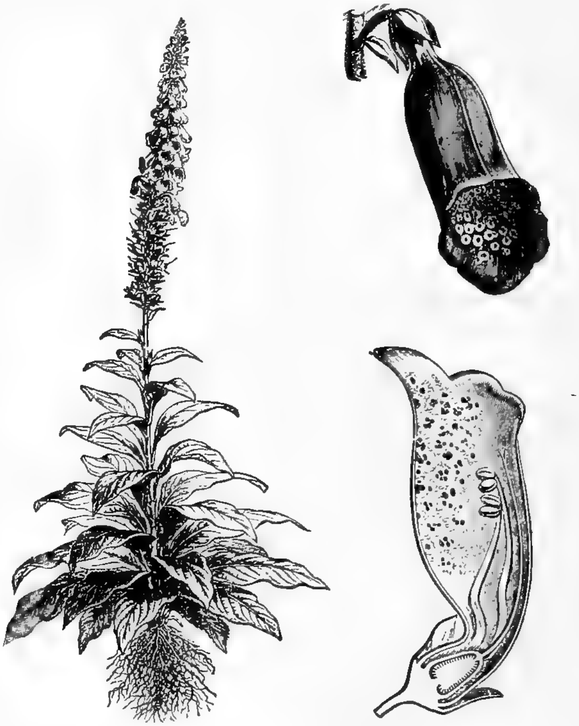

FIG. 1596.—Digitalis Purpurea Linn., Foxglove. Plant in blossom, flower slightly reduced in size, and section of flower natural size. (Baillon.)

The infusion diluted with 3 parts of water becomes turbid on the addition of a few drops of tannic acid T. S.

No other leaf probably offers greater difficulties in the matter of quality selection, and little assistance can be gained from written instructions, success coming only from long experience. This is the more unfortunate, as there is no satisfactory method of assay.

COMPOSITION.—The active constituents of digitalis are crystalline glucosides. With them, there occur resin, tannin, gum, pectin, a little sugar and digitaleic acid. Concerning the nature and occurrence of the glucosides, the discrepancy between the statements made by different investigators is so great as to preclude instructive discussion here.

"*Digitalin,*" as dispensed, is very uncertain. Not only is it usually a mixture, but the supposedly chemical body, so called, is not of a uniform character, as supplied by different manufacturers; hence, the only successful way of employing it is to use exclusively the product of the same manufacturer, and learn its therapeutic limitations. It is said by some investigators that true digitalin does not occur in the leaves, but only in the seeds; however, a substance practically identical with it does occur, and we need not consider this point. Of the formula, Merck says "$(C_5H_8O_2)N$ (?)," and he lists a "German" and a "French" product, both from *Digitalis purpurea*, but the part of the plant not stated. The former is a yellowish-white powder, soluble in water and alcohol. The dose is given as 0.001 to 0.002 gm. (gr. $\frac{1}{64}$–$\frac{1}{32}$), three or four times a day, and not to exceed gr. $\frac{1}{8}$ daily. The French article is similar, soluble in alcohol, but only in 2,000 parts of water. The dose is gr. $\frac{1}{250}$, which may be increased to a maximum of gr. $\frac{1}{40}$ daily. Both these solutions have the characteristic action of digitalis upon the heart.

Digitoxin ($C_{21}H_{32}O_7$?) is the most abundant, as well as the most active constituent. It is a white crystalline powder, soluble in alcohol, but not in water, although, by virtue of the associated bodies in the leaves, it is extracted by the infusion. The dose is gr. $\frac{1}{250}$–$\frac{1}{125}$ three times a day, and it is recommended that chloroform ♏ij., alcohol fl. ʒ i., and water ℥ iss., be taken with it. The maximum amount for the day is gr. $\frac{1}{32}$. As an enema, gr. $\frac{1}{80}$, with alcohol ♏x. and water fl. ℥ iv., is recommended.

Digitonin ($C_{31}H_{52}O_{17}$?). The presence of this in the leaves is denied. However, it is similar to saponin, and in the doses of digitalis its action is not appreciable. The same is true of digitin $(C_4H_9O_2)N$. *Digitalein* is a mixture.

In accordance with, or in spite of any, recognized facts regarding the constituents of digitalis, it is true that an alcoholic preparation, while markedly diuretic, does not exert so great a direct stimulant or irritant action upon the kidney as does the infusion.

ACTION.—The different ways in which digitalis acts upon the organs may first be considered.

1. It stimulates the muscular fibres in the cardiac and arterial walls, thus increasing cardiac force and in a double way raising blood pressure.

2. It stimulates the nerve tissues in the heart (at least the nerve endings, the action upon the ganglia being doubtful) and in the arteries, thus increasing the above-mentioned effects, but at the same time beginning to slow the heart by stimulating the ends of the vagus.

3. It stimulates the centres in the brain and cord, thus greatly increasing the slowing of the heart and still further increasing its force.

As the effects of the drug are such as I have just enumerated, it follows that well-regulated doses will restore rhythm to an irregular heart. It is probably due to this stimulation of the vagus that digitalis relieves cardiac irritability resulting from over-exertion. When high fever exists, this slowing of the heart is less apt to take place. The effects of the above-described actions have to be very carefully considered in determining the use of the drug. Its action is characteristically slow in coming on, requiring usually several hours, and the effects are similarly slow in passing off, so that when great promptness is required, digitalis is not available. One feature of the slow heart beat produced by this drug is an extension of the space required in the diastolic condition; hence when there are great accumulations of fluid encroaching upon the heart space, we must be cautious in our use of digitalis.

A more important consideration is the difference of digitalis from other cardiants in its powerful stimulation of the arterial walls. This prevents the heart strengthening from resulting in a clear gain (especially in view of its slowness), for resistance is at the same time increased. Since the increased heart action depends upon the muscular cardiac walls, it cannot so well take place when these are weakened by dilatation or fatty degeneration, or when there is aortic regurgitation, for here we simply increase resistance more than we do heart strength and thus favor backing up of the blood into the heart. Unless we can then relax the vessels in some way, it is better to substitute some other cardiant. Recent experiments made on pigs by Hare go to show that by administering digitalis carefully, increasing the dose gradually until large amounts are taken, we may bring about a great and permanent increase in the size and quality of the muscle of the healthy heart. If it shall be found, upon further trial, that this same effect can be produced in the case of a dilated heart, it can readily be appreciated how far this result will exceed all our past anticipations with regard to the usefulness of digitalis. The next most important effect of the drug is upon the kidney. It is a recognized principle that increased blood pressure favors increased renal secretion, which alone would account for the diuretic properties of digitalis; but in addition, there is a direct renal stimulation effected by irritation and by locally contracting the vessels, thus inducing an even greater local increase of blood pressure. This occurs the more easily because the substance is almost wholly excreted through the kidney. This presentation of the modus operandi of the drug is subject to certain modifications. The excessively stimulating effect upon the kidney often results in an over-contraction of the renal vessels, which checks secretion. As this state passes off, a profuse secretion comes on very suddenly. If this change does not promptly take place, the digitalis checks its own excretion and continues in the circulation, becoming cumulative in a way very different from its cumulative action upon the heart muscle already considered, and is liable to become poisonous. In a state of health, the diuretic effect of digitalis is not usually pronounced, unless the blood pressure is unusually low (Brunton).

. The other actions of digitalis are not important, except that it is very likely to irritate the stomach and intestines; this is especially true when the drug is given in the form of the infusion. Such irritation may add to the nausea or vomiting which is often caused by disturbance of the cerebral circulation; it may also produce a laxative, or even a purging effect. The cerebral disturbance may also cause dizziness, headache, disordered sight, and hearing. The uterus is stimulated. The slight antipyretic effects which digitalis produces are probably dependent upon the lessened circulation induced by slowing of the heart.

USES.—We cannot do better than to reprint Beaumont Small's account of the uses of digitalis, as given in the supplement to the last edition of this work.

"Digitalis maintains its position at the head of heart tonics. In England and America authorities are as one on this point. On the continent they are the same. Dujardin-Beaumetz assigns it the first rank and calls it 'the type of heart tonics'; Professor Nothnagel places it above all other heart tonics, and Herr Fürbringer says, 'the sovereign diuretic in cardiac disease has been, and still is, digitalis.' Continued use has confirmed the confidence placed in it, and the innumerable rivals that appear serve only to bring its superior qualities into bolder relief. Not much has been added to the uses of this remedy, but we know more definitely its proper sphere, and apply it with more precision to the conditions in which it will prove of value.

"In organic disease of the heart the guide for its use is the state of the compensatory action of that organ. It is not given as a remedy for the defective valves, nor with the expectation of benefiting any diseased condition of the organ; it is simply a stimulant and tonic to the muscular tissue. So long as the heart is able to overcome the impediment to the circulation and maintain a free flow of blood, nothing is to be gained by the use of the drug, but, with the earliest symptoms of failing power, its administration must be commenced. The system responds quickly to the first indication of this loss of compensation, the heart beats more feebly and quicker, the pulse becomes irregular, a slight degree of dyspnœa is noticed, and œdema of the feet and ankles begins. In such conditions the beneficial action of digitalis is most marked. The heart beats more slowly and forcibly and propels the blood onward, the arteries become filled, the engorged veins relieved, and the equilibrium of the circulation is re-established. This slower action of the heart allows of a prolonged period of diastole, during which it is at rest and recuperating; the succeeding contraction is rapid and strong, due to the renewed strength and stimulating action of the remedy.

"No form of organic disease contraindicates the use of digitalis when the compensatory action is failing. Its typical action is produced in mitral disease, in which it acts rapidly and for a prolonged period. In mitral stenosis it has been thought to produce a peculiarly important effect, as the prolonged dilatation of the ventricle permits a greater flow of blood from the auricle through the narrowed channel. In aortic disease it may also be given with confidence. The old idea that the prolonged diastole would allow the ventricle to become overfilled appears to be but little regarded now, as its beneficial effect outweighs any such danger. The following conclusions furnish the indications in accordance with which digitalis may be used not only in aortic, but in all forms of valvular disease: (1) In all cases of valvular disease the most important matter for consideration in regard to the heart itself is the condition of its walls in respect to dilatation and hypertrophy; (2) it must be remembered that the presence, in cardiac disease, of symptoms indicating a disturbance of the circulation always means failure of compensation; (3) it is important to ascertain, before administering the drug, that the condition of over-hypertrophy or over-compensation does not exist; (4) it must not be forgotten that the dangers in aortic disease arise from the same cause as the dangers in mitral disease, —that is, from a failure of the ventricular muscle to perform the ever-increasing work put upon it; (5) it must be admitted that if digitalis is safe and beneficial in mitral disease it is equally so in aortic disease.

"The one condition in which digitalis is contraindicated is fatty degeneration of the heart. In advanced stages of this disease, where the walls are thin and the cavities are much dilated, it must be used with extreme caution, as its action may be too violent for the feeble organ, and paralysis or rupture may follow. In the lesser degrees of degeneration, where the evidences of such a condition are indistinct, a want of action on the part of the remedy is a sign that must not be disregarded. Dujardin-Beaumetz furnishes the following rule: 'When in a patient, digitalis, administered methodically, managed with care, produces no amelioration on the part of the heart and pulse; when, above all, the quantity of urine is not augmented, be persuaded that there is a fatty degeneration of the heart and immediately cease the employment of the remedy.'

"A cumulative action, in the sense of an accumulation of the drug in the system followed by an outburst of increased action, is no longer feared. No such condition occurs. Toxic symptoms arise only from an overdose or from its prolonged administration, and the condition of poisoning is preceded by its regular train of symptoms. The first effect of digitalis is to stimulate the vagus and the vaso-motor centres, which improves the action of the heart and increases the blood pressure; this is followed by a relaxation of the vaso-motor apparatus, which is first evident in the renal vessels. Up to this point the drug produces its therapeutic action, the relaxed vessels in the kidneys, with a high arterial tension and powerful heart, furnishing all the conditions requisite for a free secretion of fluid. When the drug is pushed beyond this it produces the toxic symptoms: the renal vessels are relaxed, the reduced blood pressure extends to the general circulation, the heart becomes weaker, and the circulation fails. When a fatal termination ensues it follows a continuance of this condition and ends with a failure of the heart, which is arrested in diastole. To avoid any ill effects it is safer to discontinue the drug for a few days, as soon as its action has been established; it may be administered again when required. Where the proper conditions for its use are observed there should be no danger of any toxic action; it is only when it is employed indiscriminately that any such effect arises. A case is reported where no bad result followed its use for nearly three years, thirty-five drops being given three times a day.

"The infusion appears to remain the popular preparation, particularly when its diuretic action is required. Among the French, a maceration in cold water is the favorite form in which the drug is administered, and it is considered superior to the infusion. Five grains of powdered digitalis are macerated in four ounces of cold water for from eight to twelve hours, and then filtered. The dose is one tablespoonful every two hours. The tincture is preferred by some as a diuretic; it is probably the most useful preparation when a simple tonic action is required. Osler considers that either preparation is efficient if the drug is of good quality and given in full doses—fifteen minims of the tincture, or half an ounce of the infusion, every three hours for two days, and then in reduced quantities. The subcutaneous employment of the infusion has been recommended. In this way it has been found that very small doses will act when larger doses, given in the ordinary manner, have failed. The advantage of this method over the administration by the stomach is that usually the gastro-intestinal mucous membrane is in a catarhal and œdematous state and consequently absorption is prevented. It is also thought that the action is retarded and altered by the passage of the remedy through the liver. An infusion of three parts of the leaf in one hundred of water is prepared, and fifteen minims of this infusion are to be injected twice or three times a day. Good results, it is said, have followed this method of administering the drug.

"Digitalis, to be given early and in large doses, has been recommended as a means of aborting pneumonia. This treatment has been followed by Professor Petresco, of Bucharest, in a large number of cases. He uses an infusion of from one to three drachms of the leaves in eight ounces of water, and gives a tablespoonful every hour. As much as gr. cxx. of the leaves has been given in twenty-four hours. He states that these large doses abort the pulmonary process, shorten the attack, and hasten convalescence. The temperature in some instances drops from 105° to 96° F., and the pulse from 120 to 35 per minute. He thinks that this treatment would act almost as a specific if it could be commenced with the attack. In no instance were there any bad results, and the more severe the attack the better the action of the large doses. The good effects are due to the increased force of the circulation in the pulmonary tissue and the prevention of stasis and congestion. This can follow only when large doses are administered as early and as energetically as possible.

"Professor R. Lepine has also employed digitalin in pneumonia with success; gr. $\frac{1}{20}$ was given in the morning and often gr. $\frac{1}{60}$ or $\frac{1}{30}$ in the evening. He does not think that it has any specific action, but finds it of great value in supporting the action of a weak and feeble heart during the course of the disease."

The following are the official preparations, and their doses:—The powdered leaves are given in doses of 0.03 to 0.2 gm. (gr. ss.–iij.), and the fluid extract in the same number of minims; the extract, dose 0 02 to 0.06 gm. (gr. $\frac{1}{3}$–ij.); the fifteen-per-cent. tincture, dose 0.03 to 2.0 c.c. (♏v. to xxx.); the one-and-one-half-per-cent. infusion, dose 4 to 15 c.c. (fl ʒ i. to iv.). *Henry H. Rusby.*

DIGITALIS. (TOXICOLOGICAL.)—In the following brief account I shall use the term *digitalis* as signifying the leaves of the plant or its United States Pharmacopœia preparations.

I find records of but two cases of criminal poisoning by digitalis: one, that of a quack who caused the death of a boy by administering seven ounces of a strong decoction of digitalis; the other, the celebrated case of a homœopathic physician, La Pomerais, who was convicted of the murder of Madame de Pauw in Paris in 1864.

Fatal and non-fatal medicinal poisonings are more frequent; they are due to the cumulative action of the drug, to the great variations in the strength of its preparations, and to the fact that slight circumstances, such as rising from a bed, may provoke a fatal termination in persons who are under its influence. For these reasons it is impossible to name the minimum lethal dose.

The duration of fatal cases is usually several days. Two cases are reported in which death occurred in less than twenty-four hours, and in one case death took place in forty-five minutes.

Symptoms.—Within half an hour after a toxic dose has been taken there is a feeling of stiffness, fatigue, sleepiness, and pain in the head, followed by violent vomiting, with pain in the stomach, nausea, vertigo, and syncope, the headache becoming more intense. The heart beats rapidly and violently and a sense of suffocation is felt. The pulse diminishes in frequency, and becomes irregular and difficult to count. Visual disturbances accompany the other symptoms; among them may be mentioned dimness, oscillation and inclination of surrounding objects, and even color-blindness. The pupils are usually dilated, especially if the preparation contained much digitoxin. Sometimes there are delirium and convulsions. Although the drug generally acts as a diuretic, suppression of the urine has been observed. Death may occur in coma or convulsions, but it usually takes place suddenly from syncope provoked by some slight movement.

Treatment.—If the patient is seen in the early stages induce vomiting by large draughts of tepid water. In a more advanced stage, if vomiting is persistent, avoid giving too much drink, and administer ice fragments, opium, or cocaine. Whiskey or nitroglycerin internally, and inhalation of amyl nitrite are to be resorted to for the purpose of checking the tendency to syncope. It is very important that the patient be kept quiet in bed, avoiding all movements.

Post-mortem appearances are negative in character.

Detection.—In several cases the glucosides of digitalis have been recovered from mixtures with animal matter which had been undergoing putrefaction for four months. Digitalis can be extracted from an acid aqueous solution by benzene and chloroform.

The various substances, digitalin, digitoxin, digitonin, etc., extracted from digitalis give different color reactions. The French "digitalines," which appear to be largely digitoxin, and the leaves of the plant itself when extracted by benzene or chloroform, yield a substance which responds to the following test:

1. The substance dissolves in concentrated sulphuric acid, forming a green solution, which turns purple-red on the addition of bromine water, and upon dilution with water becomes emerald or dull green.
2. When French "digitalines" or digitoxin are added to a mixture of equal parts concentrated sulphuric acid and ethylic alcohol, and heated until the mixture turns yellow, the latter will assume a bluish-green color upon the addition of a drop of dilute ferric chloride solution.
3. The physiological reaction should be tried with frogs—or, if the quantity be sufficient, a small dog may be utilized, but not rabbits. When frogs are used, the heart is exposed and the solution injected. If digitalis be present, the frequency of the heart beats will be much diminished. Three frogs of about equal size should be prepared for purposes of comparison, one to receive an injection of known digitalis, the second the substance to be tested, and the third no injection.

In dogs digitalis produces vomiting, purging, dilatation of the pupils, slowness and irregularity of the heart's action, and, when given in sufficient quantity, death. (*Résumé.*) *Louis Warner Riggs.*

DI-HYDRO-RESORCIN is prepared by the action of carbon dioxide and sodium amalgam on resorcin dissolved in boiling water. It congeals on standing, and on recrystallization forms glossy prisms. It is very soluble in water, alcohol, or chloroform, and is recommended as an efficient antiseptic. *W. A. Bastedo.*

DI-IODO-BETA-NAPHTOL. — $C_{10}H_6I_2O_2$ — *Naphtol-aristol.* This is manufactured in the same way as aristol, beta-naphtol being substituted for thymol. The beta-naphtol is dissolved in a solution of sodium carbonate and sodium hypochlorite, and added to a solution of iodine and potassium iodide. The resulting precipitate is a yellowish-green powder without odor or taste, insoluble in water, slightly soluble in alcohol and ether, and freely soluble in chloroform. It is decomposed by heat with violet fumes. It contains 61.5 per cent. of iodine and is used like aristol as a substitute for iodoform. *W. A. Bastedo.*

DI-IODO-CARBAZOL ($C_{12}H_6I_2$:NH) is prepared by adding iodine to a hot solution of carbazol (diphenylimide). It occurs in yellow plates without odor, and is readily soluble in alcohol and chloroform but not in water. It is used as an antiseptic. *W. A. Bastedo.*

DI-IODOFORM.—C_2I_4—Ethylene tetra-iodide or periodide. This is obtained in fine, bright-yellow needles by acting with excess of iodine on a solution of acetylene iodide in carbon bisulphide. It is odorless, insoluble in water, very slightly soluble in alcohol and ether, and readily so in chloroform or benzol. It contains a very large amount of iodine (95.28 per cent.), part of which is set free on exposure to light, giving a characteristic odor and color to the drug. It is a succedaneum for iodoform, which contains 96.54 per cent. of iodine. *W. A. Bastedo.*

DI-IODO-SALICYLIC ACID.—($C_6H_2I_2$,OH,COOH) is a white crystalline powder of sweet taste prepared from salicylic acid by the action of iodine and iodic acid. It is almost insoluble in cold water, slightly soluble in hot water, and very soluble in alcohol and ether; its salts are soluble in water. Used in the same way as the salicylates, this acid and its sodium salt act as analgesics and antipyretics, especially in rheumatic conditions. The dose is 0.5–1 gm. (gr. viij.–xv.) three or four times a day. *W. A. Bastedo.*

DI-IODO-SALOL. — $C_6H_2I_2$,OH,COOC_6H_5 — Di-iodophenyl salicylate. This salt is obtained by the action of iodine on salol in alcoholic solution. It occurs in acicular crystals which are colorless, odorless, tasteless, and soluble in alcohol. It contains sixty-five per cent. of iodine and externally is used to replace iodoform. Internally it is said to be an efficient intestinal antiseptic, and is used for the same purpose and in the same dose as salol. *W. A. Bastedo.*

DILL OR DILL FRUIT.—*Anethum.* "Dill-seed". The fruit of *Anethum graveolens* L. (fam. *Umbelliferæ*), a European annual, with a slender, low, branching stem and dissected leaves, and with flowers and fruits in compound non-involucrate umbels. Dill is raised in gardens as a household aromatic, and is official in Great Britain as the source of *Aqua Anethi* and *Oleum Anethi* of that Pharmacopœia. The description of its fruit is as follows: "Broadly oval, about one-sixth of an inch long, flat, and surrounded by a broad membranous border. It has a brown color, the membranous border being paler. The half fruits, or mericarps, are usually distinct in the fruits of commerce. Odor and taste agreeably aromatic."

Dill contains an agreeable *essential oil,* composed of a hydrocarbon and carvol (Nietzki). Its action and use are exactly those of anise, caraway, and the other umbelliferous carminatives, from which it differs only very slightly in taste and odor. *W. P. Bolles.*

DI-METHYL-ACETAL. — $CH_3CH(OCH_3)_2$ — Ethylidene-di-methyl ether. This is a colorless, inflammable, ethereal liquid prepared by acting on methyl alcohol with glacial acetic acid and aldehyde. Its specific gravity is 0.867, it boils at 62.7° to 64° C. (145°–147.2° F.), and is a local anæsthetic. Mixed with half its volume of chloroform it has been used as a general anæsthetic, but clinical reports are wanting. *W. A. Bastedo.*

DI-OXYNAPHTHALENE.—$C_{10}H_6(OH)_2$—Hydro-naphtho-quinone. The alpha and beta modifications of this chemical in amounts up to 0.2 gm. (gr. iij.) a day have been found by Lepine to act as powerful tonics increasing muscular energy. In overdose they cause in dogs and guinea-pigs convulsions, reduction of the hæmoglobin, and blackish urine. *W. A. Bastedo.*

DIPHTHERIA.—HISTORY.—The specific contagious disease which we now call diphtheria, and, therefore, according to our present belief, the bacilli which cause it, can be traced back to almost the Homeric period of Grecian history. The Greeks believed that it had been communicated to their country from Egypt. The description of the pharyngeal and laryngeal manifestations of this disease left by Aretæus leaves no doubt that it was of diphtheria that he wrote. Galen, in his remarks on the Chironian ulcer, tells us that the pseudo-membrane was gotten rid of by coughing in the laryngeal form of the disease, and by hawking in the pharyngeal type. From time to time during the next one thousand years we hear of epidemics both in Italy and in other portions of the civilized world. In 1517 we read of a malignant form of the disease raging in Switzerland, along the Rhine, and in the Netherlands. The disease now crossed to America, and in the New England States we get clear accounts of its ravages. Thus, Samuel Danforth, in 1659, lost four of his eleven children within a fortnight by a "malady of the bladders in the windpipe." In 1765, Home, a Scotchman, tried to show that "croup" and pharyngeal diphtheria were different diseases, or, in bacteriological terms, due to different micro-organisms, and this subject remained under controversy until it was recently settled that while most cases were undoubtedly true diphtheria, a few were not.

Bard, an American, supported, in 1771, the opposite theory from Home, considering the process the same wherever located. In this ground he was much nearer to the facts than Home. His observations upon diphtheria were very important and accurate.

In 1821, Bretonneau published his first essay on diphtheria in Paris and gave to the disease its present name. His observations were so extensive and so correct that little advance in knowledge took place until the causal relations of the diphtheria bacilli and their associated micro-organisms to the disease began to be recognized. Since then the combined clinical, bacteriological, and pathological studies have sufficed to make diphtheria one of the best understood of diseases.

BACTERIOLOGY.—*The Bacillus of Diphtheria.*—In the year 1883 bacilli which were very peculiar and striking in appearance were shown by Klebs to be of constant occurrence in the pseudo-membranes from the throats of those dying of true epidemic diphtheria. One year later, Löffler published the results of a very thorough and extensive series of investigations on this subject. He found the bacillus described by Klebs in many cases of throat inflammations which had been diagnosticated as diphtheria. When he inoculated the bacilli upon the abraded mucous membrane of susceptible animals, more or less characteristic pseudo-memberranes we produced, and frequently death or paralysis followed, with characteristic lesions.

All the conditions have since then been fulfilled for diphtheria which are necessary to the most rigid proof of the dependence of an infective disease upon a given micro-organism—viz., the constant presence of this organism in the lesions of the disease, the isolation of the organism in pure culture, the reproduction of the essential lesions of the disease in animals and in man by inoculation with pure cultures, the failure to produce all the characteristic lesions of this disease by any other bacteria, and the additional proof of the immunizing value of the specific substances developed in animals subjected to injections of diphtheria toxin. In view of these facts we are now justified in saying that the name diphtheria, or at least primary diphtheria, should be applied, and exclusively applied, to that acute infectious disease usually associated with pseudo-membranous affection of the mucous membranes which is primarily caused by the Bacillus diphtheriæ of Löffler. Other bacteria do, indeed, occasionally produce local lesions which simulate in one way or another those caused by the diphtheria bacillus, but none of them ever produce lesions similar in their totality to those of a characteristic case of diphtheria. As the diphtheria bacilli have been quite fully described in Vol. I., p. 694, only those points will be given here which need to be more fully stated, on account of their important relations to diagnosis and treatment.

The Klebs-Löffler bacilli *stain* readily with ordinary aniline dyes, and retain fairly well their color after staining by Gram's method. When Löffler's alkaline solution of methylene blue is applied cold for five minutes or warm for one minute the bacilli from blood-serum cultures especially, and from other media less constantly, stain in an irregular and extremely characteristic way. Many of the bacilli do not stain uniformly. In many cultures round or oval bodies situated at the ends or in the central portions stain much more intensely than the rest of the bacillus. These bodies have been shown by Williams to bear much the same relations to the bacilli as nuclei do to cells. In old cultures the bacilli stain poorly and not at all in a characteristic way. The same round or oval bodies which take the methylene blue more intensely than the remainder of the bacillus are brought out still more distinctly by the Neisser stain. (See Vol. I., Plate X., Fig. 4, and page 695.)

The Neisser stain has been advocated in order to separate the virulent from the non-virulent bacilli without the delay of inoculating animals; but in our hands, with a very large experience, neither the Neisser stain nor any other stain is capable of doing this, and none appear to me to give any more information as to the virulence of the bacilli than the usual methylene-blue solution of Löffler. A small percentage of virulent bacilli fail to take the Neisser stain, and quite a few non-virulent pseudo-diphtheria bacilli show the dark bodies. In New York there are also a large number of bacilli which seem to have all the staining and cultural characteristics of the virulent bacilli, and yet are non-virulent in the sense that they produce no specific toxin. The Neisser stain will undoubtedly cause the examiner to suspect more strongly some bacilli of being virulent than the Löffler stain, but with the varieties met with in New York this suspicion is as apt to be wrong as right. Nothing but the animal inoculations with control injections of antitoxin will separate specifically virulent from non-virulent bacilli.

Biology.—The Klebs-Löffler bacillus does not form spores. Its thermal death point with ten minutes' exposure is about 58° C., and with longer exposure a lower temperature; it is more easily destroyed by disinfectants than are many other bacteria. In the dry state and exposed to diffuse light diphtheria bacilli usually die in a few days but occasionally may live for weeks or months; when in the dark, or protected by a film of mucus or albumin, they may live for even longer periods. The bacillus is not sensitive to cold, for I found it to retain its virulence after exposure for two hours to several hundred degrees below zero. It begins to develop, but grows slowly, at a temperature of 20° C., or even less. It grows more rapidly as the temperature rises, and attains its maximum development at 37° C.

The growth of the diphtheria bacillus upon agar presents certain peculiarities which are of practical importance in connection with cultures for diagnosis. If a large number of the bacilli from a recent culture are implanted upon a properly prepared agar plate, a certain and fairly vigorous growth will always take place. If, however, the agar is inoculated with an exudate from the throat which contains but few bacilli, no growth whatever may occur, while the tubes of coagulated blood serum inoculated with the same exudate contain the bacilli abundantly. Because of the uncertainty, therefore, agar is a far less reliable medium than blood serum for use in primary cultures for diagnostic purposes.

Growth in Ascitic Bouillon: Diphtheria bacilli can almost be divided into two great groups: one growing readily in bouillon, while the other scarcely grows at all when first removed from the throat. All varieties, however, develop luxuriantly when to the bouillon twenty-five per cent. ascitic fluid or blood serum is added. Lately this fact has been made use of with great success in getting pure cultures of diphtheria bacilli from throat cultures when virulence tests are desired. The ascitic bouillon is inoculated with the mixed bacteria from the original culture from the throat; after twenty-four or forty-eight hours a pellicle will develop if any diphtheria bacilli were present in the material inoculated. This pellicle will be found to be composed almost wholly of diphtheria bacilli. Plate cultures are then made and the bacilli readily isolated.

Growth in Milk: The diphtheria bacillus grows readily in milk, beginning to develop at a comparatively low temperature (20° C.). Thus milk having become inoculated with the bacillus from some cases of diphtheria may under certain conditions be the means of conveying infection to previously healthy persons. Though this growth takes place, the milk remains unchanged in appearance.

Pathogenesis.—The diphtheria bacillus is pathogenic for guinea-pigs, rabbits, chickens, pigeons, small birds, and cats; also in a lesser degree for dogs, goats, cattle, and horses, but hardly at all for rats and mice. In spite of its pathogenic qualities for these animals true diphtheria occurs in them with extreme rarity. I have met with one cat which had typical diphtheria and from which the diphtheria bacilli were isolated and proved virulent. As a rule, supposed diphtheritic inflammations in them are due to other bacteria which cannot produce the disease in man.

The virulence of diphtheria bacilli from different sources, as measured by their toxin production, may vary enormously. Thus 0.002 c.c. of a forty-hour bouillon culture of one bacillus will kill a guinea-pig, while it would require 1 c.c. of the culture of another bacillus to kill. From well-marked cases in New York, however, the bacilli have as a rule about the same virulence, nor did they lose in virulence to any great extent when they persisted in the throat secretions after convalescence. The same marked variation occurs in the amount of toxin produced by different bacilli in their growth in media outside of the body. There are also bacilli which produce no specific toxin whatever and yet appear to have all the other characteristics of virulent bacilli.

Diphtheria Toxin.—It is evident that a micro-organism which, when injected subcutaneously, destroys the life of susceptible animals and produces such marked anatomical changes in the internal organs, while it is found only at or near the point of inoculation, must owe its pathogenic power to the formation of a poison which, being absorbed, gives rise to toxæmia and death. This poison or *toxin* has been partially isolated by Roux and Yersin, and others, by filtration through porous porcelain from cultures of the living bacilli. It has not yet been successfully analyzed, so that its chemical composition is unknown, but it has many of the properties of proteid substances, and can well be designated by the term active proteid.

Non-Virulent Diphtheria Bacilli.—In the very large number of tests for virulence of the bacilli obtained from hundreds of cases of suspected diphtheria which have been carried out during the past six years in the laboratories of the Health Department of New York City, in over ninety-five per cent. of cases the bacilli derived from exudates or pseudo-membranes and possessing the characteristics of the Löffler bacilli have been found to be virulent, that is, producers of diphtheria toxin. But there are, however, in inflamed throats as well as in healthy throats, either alone or associated with the virulent bacilli, occasionally bacilli, which, though morphologically and in their behavior on culture media identical with the Klebs-Löffler bacillus, are yet producers, at least in artificial culture media and the usual test animals, of no appreciable diphtheria toxin. Between bacilli which produce a great deal of toxin and those which apparently produce none we find all grades of virulence. So far as we know, bacilli which produce no specific toxin have never later been found to develop it. Bacilli are also found which resemble diphtheria bacilli very closely (except in toxin production), but differ in one or more particulars. Both these and the characteristic non-virulent bacilli are found occasionally upon all the mucous membranes, both when inflamed and when apparently normal.

Virulent bacilli produce and are found not only in pseudo-membranous inflammations of the fauces, larynx, and nasal cavities, but also occasionally in membranous affections of the skin, vagina, rectum, conjunctiva, nose, and ear (simple membranous rhinitis and otitis media). From the severity of an isolated case the virulence of the bacilli cannot be determined. The most virulent bacillus I have ever found was obtained from a mild case of diphtheria simulating tonsillitis. Another case, however, infected by this bacillus proved to be very severe. In localized epidemics the average severity of the cases probably indicates roughly the virulence of the bacillus causing the infection, as here the individual susceptibility of the different persons infected would, in all likelihood, when taken together, be similar to that of other groups; but even in this instance special conditions of climate, food, race, or concurrent infections may influence certain localities. Moreover, the bacteria associated with the diphtheria bacilli, and which are liable to be transmitted with them, may influence the severity of and the complications arising in the cases.

Virulent Bacilli in Healthy Throats.—Fully virulent bacilli have frequently been found in healthy throats of persons who have been brought in direct contact with diphtheria patients or infected clothing without contracting the disease. It is therefore apparent that infection in diphtheria, as in other infectious diseases, requires not only the presence of virulent bacilli, but also a susceptibility to the disease, which may be inherited or acquired. Among the predisposing influences which contribute to the production of diphtheritic infection may be mentioned the breathing of foul air and living in overcrowded and ill-ventilated rooms, poor food, certain diseases, more particularly catarrhal inflammations of the mucous membranes, and depressing conditions generally. Under these conditions an infected mucous membrane may become susceptible to disease. In connection with Beebe (1894) I made an examination of the throats of 330 healthy persons who had not come in contact, so far as known, with diphtheria, and we found virulent bacilli in 8 only, 2 of whom later developed the disease. In 24 of the 330 healthy throats non-virulent bacilli or attenuated forms of the diphtheria bacillus were found. Very similar observations have been made by others in many widely separated countries.

The Persistence of Diphtheria Bacilli in the Throat.—The continued presence of virulent diphtheria bacilli in the throats of patients who have recovered from the disease, and after the disappearance of the exudate, has been repeatedly demonstrated. Beebe and I found that in 304 of 605 consecutive cases the bacilli disappeared within three days after the disappearance of the pseudo-membrane; in 176 cases they persisted for seven days, in 64 cases for twelve days, in 36 cases for fifteen days, in 12 cases for three weeks, in 4 cases for four weeks, and in 2 cases for nine weeks. Since then I have met with a case in which they persisted for six months.

Mixed Infection in Diphtheria.—Virulent diphtheria bacilli, however, are not the only bacteria present in human diphtheria. Various cocci, more particularly streptococci, staphylococci, and pneumococci, are almost always found associated with Löffler bacilli in diphtheria, playing an important part in the disease and leading often to serious complications (sepsis and broncho-pneumonia). Indeed, the prognosis in a case of diphtheria is now judged to be graver, other things being equal, according to the degree in which other pathogenic bacteria influence the course of the disease. These cases of so-called *mixed infection* in diphtheria have within recent years attracted considerable attention, and have been the subject of a number of animal experiments. Though the results of these investigations so far have been somewhat indefinite, they would seem to indicate that when other bacteria are associated with the diphtheria bacilli they mutually assist one another in their attacks upon the mucous membrane, the streptococcus being particularly active in this respect, often opening the way for the invasion of the Löffler bacillus into the deeper tissues or supplying needed conditions for the development of its toxin. Thus diphtheria is not always a primary, but often a secondary disease, following some other infection, as measles or scarlet fever. In most fatal cases of broncho-pneumonia following laryngeal diphtheria we find not only abundant pneumococci or streptococci in the inflamed lung areas, but also in the blood and tissues of the organs. As these septic infections due to the pyogenic cocci are in no way influenced by the diphtheria antitoxin, they frequently are the cause of the fatal termination. Other bacteria cause putrefactive changes in the exudate, producing alterations in color and offensive odors.

Pseudo-membranous Exudative Inflammations due to Bacteria other than the Diphtheria Bacilli.—The diphtheria bacillus, though the most usual, is not the only micro-organism that is capable of producing pseudo-membranous inflammations. There are numerous bacteria present almost constantly in the throat secretions which, under certain conditions, can cause local lesions very similar to those in the less marked cases of true diphtheria. The streptococcus and pneumococcus are the two forms most frequently found in these cases, but there are also others which, under suitable conditions, take an active part in producing this form of inflammation. Some of these bacteria do not develop on artificial media, so that we know little of their characteristics. Among these is a long, slender bacillus which is occasionally found in great abundance in the middle layers of pseudo-membranes when the diphtheria bacillus is absent. This, or one similar to it, has been described by Vincent.* It does not grow on artificial media and is not pathogenic in animals. From its presence in the false membrane of a number of cases, it is believed to have some causal relation to them.

These cases show most of the local appearances of true diphtheria: the superficial necrosis of the epithelium, the membrane, and the glandular swellings. The pseudo-membranes may persist for from one to two weeks, or even, in exceptional cases, longer. This bacillus is apparently frequently present in the normal throat, and is probably only under certain favoring conditions, such as syphilis, able to produce lesions. Nerve degeneration and paralysis do not follow an attack.

The pseudo-membranous angina accompanying scarlet fever, and to a less extent other diseases, may show the presence not of diphtheria bacilli, but only of the pyogenic cocci, especially streptococi, or, more rarely, some varieties of little known bacilli. The deposit covering the inflamed tissue in these non-specific cases is, it is true, usually but not always, rather an exudate than a true pseudo-membrane. The majority of these cases, however, are mild affections, being of importance only in adding to the severity of the disease which they complicate. An exception should be made when the larynx is affected, as here the lungs are often secondarily involved. The bacteria which occur in *false diphtheria* are streptococci, staphylococci, diplococci, and sometimes pseudo-diphtheria bacilli or bacilli which are morphologically and culturally distinct from the Löffler bacilli. These will be referred to further under their respective organisms.

The Transmission of Diphtheria.—The possibility of the transmission of diphtheria from animals to man cannot be disputed, for cats and many animals can be infected, but, so far as I know, there are no authentic cases of such transmission on record. So-called diphtheritic disease in animals and birds is usually due to other micro-organisms than the diphtheria bacilli. Diphtheritic infection, however, can generally be traced, directly or indirectly, to its source; though there are undoubtedly some cases of diphtheria in which we cannot determine the source of the infection, for we have no reason to believe that diphtheria is ever spontaneous.

Let us consider some of the means by which the disease may be communicated. In actual experiment the bacilli have been observed to remain virulent in bits of dried membrane by Löffler for fourteen weeks, by us for seventeen weeks, and by Roux and Yersin for twenty weeks. Dried on silk threads Abel reports that they may sometimes live one hundred and seventy-two days, and upon a child's plaything which had been kept in a dark place they lived for five months. The virulent bacilli have been found on soiled bedding or clothing of a diphtheria patient, on drinking-cups, shoes, hair, slate pencils, etc. Beside these sources of infection by which the disease may be indirectly transmitted, virulent bacilli may be directly received from the pseudo-membrane, exudate, or discharges of diphtheria patients; from the secretions of the nose and throat of convalescent cases of diphtheria in which the virulent bacilli persist; and from the healthy throats of individuals who acquired the bacilli from being in contact with others having virulent germs on their persons or clothing. In such cases the bacilli may sometimes live and develop for days or weeks in the throat without causing any lesion. When we consider that it is only the severe types of diphtheria that remain isolated during their actual illness, the wonder is not that so many, but that so few, persons contract the disease. It indicates that very frequently virulent bacilli are received into the mouth, and then either find no conditions there suitable for their growth or are swept away by food or drink before they could effect a lodgment.

Susceptibility to and Immunity against Diphtheria.—An individual susceptibility, both general and local, to diphtheria, as in all infectious diseases, is necessary for the contraction of this disease. Moreover, the diphtheria poison does not produce the same effect on the mucous membranes of all persons. Age has long been recognized to be an important factor in diphtheria. Children within the first six months of life are but little susceptible, the greatest degree of susceptibility being between the third and the tenth years, while adults are almost immune. An inherited susceptibility or "family predisposition" to the disease has also been observed.

Long before the discovery of the Klebs-Löffler bacillus it was a well-known fact that two attacks of diphtheria seldom occurred in the same individual within short periods of time, and none of us would fear to leave a convalescent case in the same room with one still suffering from the disease. To what this natural susceptibility or immunity is due is still only partially understood, but, as the result of animal experiments, it is now known that an artificial immunity against diphtheria can be produced, at least for a considerable length of time, by the development of substances directly antidotal to the diphtheria toxin. By the inoculation of virulent or somewhat attenuated cultures or of diphtheria toxin, Fraenkel, Behring, Wernicke, Aronson, Roux, and since then many others, have succeeded in immunizing animals; but the most important and valuable results are those which have been obtained by Behring, in conjunction with others, who showed that the blood of immune animals contains a substance which neutralizes the diphtheria toxin. The blood serum of persons who have recovered from diphtheria has been found also to possess this protective property, which it acquires about a week after the beginning of the disease, and loses again in a few weeks or months. Moreover, the blood serum of many individuals, usually adults, who have never had diphtheria often has a slight general antitoxic property.

Antitoxin Serum.—The knowledge derived from these remarkable investigations into the protective powers of the blood serum of immunized animals has been employed with the most brilliant results for the prevention and early treatment of diphtheria in man. For the methods employed to obtain diphtheria antitoxic serum see Vol. I., page 698.

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* Annales de l'Institut Pasteur, August, 1899.

PATHOLOGY.—*Location of Bacilli in the Membrane.**—We have never found the diphtheria bacilli growing in the living tissue, or in connection with those degenerative lesions in the epithelium which can be regarded as the primary lesions of the disease. They were found in the necrotic tissue and in the exudation, usually only in the latter. In a very few cases the bacilli were found enclosed in pus and in necrotic epithelial cells. They were nearly always found in clumps and masses. The masses found deep down in the membrane probably do not represent a downward growth in this, but have been covered up by a further formation of membrane on the surface. The diphtheria bacillus shows in its growth an affinity for solid structures, and is found rather on the reticulum than in the spaces between.

Usually other organisms, particularly the pyogenic cocci, are found associated with it, though not intimately. The membrane and necrotic tissue may also be invaded by fungi.

Membrane Formation.—This is due to a combination of processes. It seems probable that the first step in its production is degeneration and necrosis of the epithelium, often preceded by active proliferation of the nuclei of the cells by direct division. The cells may either break up into detritus, with fragmentation of the nuclei, or they may become changed into refractive hyaline masses. An inflammatory exudation rich in fibrin factors comes from the tissue below, and fibrin is formed when this comes in contact with the necrotic epithelium. The fibrin in part is formed into a reticulum around exudation cells and degenerated epithelium, in part it combines with the hyaline degenerated cells to form a hyaline membrane. The hyaline membrane is most often formed on those surfaces which are covered with epithelium having several layers of cells. It may be formed by a hyaline degeneration of exudation cells; in this case the spaces in the meshwork are smaller. It is probable that the fibrinous membrane is formed both on the surfaces and in the tissue. The fibrin is first formed around cells which afterward disappear. In the trachea the fibrinous membrane often has a definite structure. The membrane may disintegrate and be broken up into a mass of detritus (the process commences on the surface), or it may be cast off as a whole by being elevated by an exudation beneath. Very thick masses of membrane may be formed by the constant addition of fibrinous exudation. The membrane is never formed primarily on an intact epithelial surface, but it may extend over it. Nothing is to be gained by making an anatomical distinction between a croupous and a diphtheritic membrane. There is nothing specific in the membrane formation in diphtheria. We have found typical hyaline and fibrinous membranes in cysts of the ovary in the formation of which bacteria played no part.

The membrane formation is accompanied by changes in the tissue beneath, which represent a combination of degeneration and exudation. The connective tissue and blood-vessels undergo a hyaline, fibrinoid degeneration very similar to the degeneration of the epithelium. Necrosis may extend deeply into the tissue, but there is little tendency to deep ulceration or abscess formation. The degeneration in the mucous glands of the tissue is so pronounced as to be almost specific. Marked degeneration of the epithelium of the glands may be found without any change in the surrounding tissue. The changes in the blood-vessels, though so pronounced in diphtheria, are not specific. We have frequently found changes in all respects similar in the walls of abscesses and ulcers. The extent of the necrosis in the primary lesions is greater than is found in the action of any other bacteria.

Heart.—Degeneration of the myocardium is one of the most common conditions found in diphtheria. The simplest form of this is fatty degeneration, which is found in the majority of all cases. This varies in extent, at times affecting the myocardium generally, at other times occurring in foci. The fatty degeneration accompanies and seems to precede the more advanced forms of degeneration which lead to the complete destruction of the muscle. In this there is destruction of the sarcous elements, which become swollen, broken up, and converted into hyaline masses. Simple fatty degeneration is found in the severe cases of short duration, the more extensive degenerations in the more prolonged cases. The degenerations may be so extensive as to account fully for the impairment of the heart action. No bacteria are found in connection with the degeneration, but like most of the lesions of the disease it is due to the influences of the toxic substances in the blood.

Acute interstitial lesions of two sorts are found. In one there are focal collections of plasma and lymphoid cells in the tissue, which may be accompanied by degeneration of the myocardium, but are not dependent upon it. In the other condition the interstitial change consists of a proliferation of the cells of the tissue and is secondary to the degeneration of the muscle.

Thrombosis is not an uncommon condition and is due to primary necrosis of the endocardium. Lesions of the vessels of the heart play but little part; the only lesion of interest is proliferation of the intima, the same lesion which is frequently found in the vessels in other organs.

Lungs.—There is no organ in the body in which lesions accompanying diphtheritic infection are so generally found or so serious as in the lung. In very many cases they are so extensive that death may be regarded as due rather to the condition of the lungs than to the throat affection. We have frequently found extensive lesions on microscopical examination even when the lungs presented little or no change to the naked eye. It seems probable that the frequency of these lesions may be due to the fact that most or all of our cases were treated with antitoxin, and that those in which the lung complications were not present, or at least not severe, recovered.

The most common lesion is broncho-pneumonia. The term implies both the manner in which infection takes place and the relation of the foci to the bronchi. The process begins as an infection of the atria and from here extends. It may be limited to single acini, to lobules, or to groups of lobules. There is but little lateral extension of the infection through the walls of the alveoli or the bronchi into the surrounding air spaces. Acute inflammation of the larger bronchi usually accompanies the broncho-pneumonia, but is not constant. Atelectasis varying in extent from one to several lobules, or even confined to a few air spaces, is very commonly present. The same is true of emphysema. True acute lobar pneumonia was never found. The cases resembling this were found on closer examination to be cases of extensive confluent broncho-pneumonia. General œdema of the lung comparable to the circulatory œdema of adults was never found, although inflammatory œdema was common. The character of the exudation varies greatly. It may be fibrinous, hemorrhagic, serous, or almost entirely cellular. The cells in the exudation are partly leucocytes, partly cells derived from proliferation of the lining epithelium. Lymphoid and plasma cells also are found in the exudation. Cellular infiltration of the interstitial tissue and productive changes in it are common, both in connection with the acute exudative lesions and apart from them. In some cases organization of the exudation and the formation of connective tissue within the air spaces were found. Proliferation of the lining epithelium of the air spaces is frequent, and is always more pronounced in the vicinity of the pleura and the connective-tissue septa.

Thrombi are occasionally found in the larger vessels. Dilatation of the lymphatics is very common. They may contain coagulated albumen, fibrin, or cells. They are often found packed with lymphoid and plasma cells, and large cells similar to the large cells in the air spaces.

Nothing has shown so well how little the character of a pathological process is influenced by the character of the micro-organism as has the examination of these lungs. Pneumococci, streptococci, and diphtheria bacilli have been found in connection with serous, purulent, fibrinous, and hemorrhagic exudations, necrosis, and abscess formation. Contrary to the results obtained from cultures, the pneumococcus must be considered the principal agent in producing the lung infection. The diphtheria bacilli are frequently found and may be the cause of bronchitis with membrane formation, of purulent exudation, of broncho-pneumonia, necrosis, and abscess. They are often found in the lung in much greater numbers than in any other situation, and there may be but little change in the tissue around them.

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* The section on Pathology is largely a summary of the recent and excellent monograph by Councilman, Mallory, and Pearce (Journal of the Boston Soc. of Med. Sciences, December, 1900).

Spleen.—Lesions of the spleen play but a slight part in the pathological anatomy of diphtheria. The spleen macroscopically does not differ from the normal, except that the lymph nodules usually are more prominent. The most obvious lesion microscopically consists of the formation, in the lymph nodules, of foci of epithelioid cells which are of the same character and formed in the same way as those in the lymph nodes.

Intestines.—The lesions of the small and large intestine in diphtheria in man are relatively unimportant. They consist of hyperplasia of the lymphoid apparatus and the same other changes found in the lymph nodules elsewhere. The slight extent of the lesions does not indicate the action of toxins absorbed from the alimentary canal; they are probably due to the action of toxins from the blood current. There is nothing in the character of the lesions to indicate the elimination of the toxins by the alimentary canal.

Liver.—The lesions produced in the liver in diphtheria are not characteristic, and do not differ from those found in other acute infectious diseases. They are due to the effect of soluble toxic substances, and not to the presence of diphtheria bacilli. The most common lesions are a general degeneration of the liver cells, and necroses which are chiefly found in the centres of the lobules.

Kidney.—Lesions of the kidney varying from simple degeneration to the more serious conditions of acute nephritis are found in all fatal cases of diphtheria. Some of the lesions are somewhat more common in the mixed infections of diphtheria combined with scarlet fever than in pure diphtheria. The more severe forms of degeneration are found in those cases of diphtheria of great intensity which are fatal shortly after the onset.

The interstitial and glomerular lesions are more common in older children and in cases of longer duration of the disease, though these conditions usually are combined. There is no type of lesion peculiar to diphtheria. The lesions in the kidneys are not due to the presence of bacteria in the blood, but to the action of injurious substances in solution in the blood.

Nervous System.—All of the nerves in the twenty-eight cases examined showed various degrees of fatty degeneration, from slight to extreme. The degeneration seems almost invariably to begin in the myelin sheath.

As a rule the change in the myelin which causes it to stain with osmic acid in the Marchi method, begins at some point close to the axis cylinder and gradually spreads around and along it. The myelin breaks up into granules, droplets, and very irregular bizarre figures of which the peripheries usually are more refractive than the centres and often doubly contoured. As a rule the centres of the masses stain more deeply than the peripheries, but sometimes small black globules with pale centres appear.

The change in the axis cylinder seems to consist chiefly of swelling which is often irregular, so that the axis cylinder presents a beaded appearance. As it swells it stains very faintly, so that it is often difficult and sometimes impossible to make it out. When the myelin sheaths have undergone marked fatty degeneration, the axis cylinders usually cannot be distinguished. Whether they have simply swelled up and disappeared, or have undergone fatty degeneration, is difficult to determine; but in no axis cylinder which could be positively demonstrated was there any evidence of fatty degeneration.

Examination of the cerebrum five times, cerebellum twice, pons three times, medulla four times, and cord seven times, showed everywhere a slight to marked diffuse fatty degeneration of the white substance. The same change was present in the anterior and posterior nerve roots.

The results of the investigation of the nervous system may be summed up as follows: There occurs in certain cases of diphtheria a slight to marked diffuse fatty degeneration of the nerve fibres of the central nervous system and of its peripheral extensions.

SYMPTOMS.—*Pharyngeal Diphtheria.*—Mild Cases: Those in which the local lesions are moderate in degree and in which the constitutional symptoms are not serious. These may be divided into two classes. In the first the onset is sudden; the temperature rises possibly to 103° F. in the first twelve hours and then rapidly falls, so as to reach the normal one or two days later. With the rise of the temperature the throat symptoms develop. The mucous membranes appear hyperæmic and congested, and after a few hours more or less extensive patches appear on the swollen tonsils, soft palate, pharynx, or uvula. The local symptoms increase for twenty-four hours and then remain stationary. With the rise in temperature and the local signs of inflammation there are rapid pulse, loss of appetite, and some prostration. At the end of forty-eight hours the constitutional symptoms abate. The temperature is rarely above 101° F. The pulse may still be rapid, but is regular and of good force. The local inflammation subsides in from three to seven days, and the patient is fairly well except for a slight anæmia. Even in these mild cases feebleness of pulse and heart beat may develop and danger of heart failure be present.

In the second class the throat inflammation develops slowly. There is a little pain on swallowing. The glands at the angle of the jaw are usually a little swollen and the throat feels sore. Inspection will show slightly swollen tonsils, with follicular deposits of exudate or small patches of pseudo-membrane. The temperature is not elevated more than one or two degrees or it may be normal. Except for slight loss of appetite, restless sleep, and slight prostration the symptoms are mainly those of a subacute throat inflammation. The exudate may be strongly adherent, so that it can be removed by force only, or it may be loosely attached. The diphtheria deposit remains for from two to seven days, and then recovery is established. A moderate amount of anæmia persists for some weeks. Some cases in either of these two types may, instead of recovering, suddenly begin to extend and develop into the most severe type. Even in these mild cases slight paralysis may occur as late as three weeks after apparent recovery.

Severe Cases: Here, again, two extreme types of invasion are noted: the local and constitutional symptoms may slowly develop, or they may become fully developed within the first twenty-four to forty-eight hours, either with or without high temperatures. In exceptional cases a chill is the first symptom noticed.

The mind is usually clear, although in the worst cases mild delirium or stupor may develop. The mucous membrane of the pharynx and tonsils is reddened and swollen. The uvula may be œdematous, elongated, and greatly swollen. Portions or all of the mucous membrane of the tonsils, the pharynx, and the soft palate are covered with more or less thick and fibrinous pseudo-membrane of a grayish color. The glands of the neck and their adjacent tissues may be slightly or markedly swollen. If the nasal cavities are involved, the breathing and voice are affected. From the nose flows a discharge which may be of an intensely irritant character. The nasal obstruction may be partial, in which case the irrigating fluid passes easily, or it may be total, so that it is possible to force fluid through the nose only under high pressure.

After from forty-eight to seventy-two hours the fever, if present, commonly subsides. In favorable cases the pulse becomes less frequent, and remains of fair force and regularity. The appetite improves and the intellect remains clear. After forty-eight hours the local symptoms remain stationary up to the fifth day, and then the swelling subsides; the membrane begins to loosen at the edges, and soon peels off, leaving a superficially ulcerated surface, or it may more gradually melt away. The glands of the neck decrease in size, and the patient is convalescent and certain to recover unless dangerous paralysis develops.

In other cases the course of the disease is unfavorable. The temperature may fall nearly to the normal, but the pulse becomes more rapid, feeble, and irregular, or it may in certain toxic cases suddenly for a time become very slow—40 to 50 to the minute. Before death the heart's action usually becomes more irregular and rapid. Other patients grow apathetic. The urine is apt to be scanty and contain albumin and casts. These patients may suddenly develop uræmic convulsions and die, or may gradually waste away. Some develop a persistent nausea and vomit all food. Others suffer from paralysis of deglutition and of the muscles of respiration. Still others seem to be recovering from the diphtheria when the symptoms and physical signs of pneumonia develop. The temperature then rises to 103° or 104° or even 106° F.

In other cases the false membrane does not limit itself to the pharynx but spreads to the larynx. These patients then have, in addition, the special symptoms due to obstruction to the breathing. Finally, there is a group of cases that seem to be fatal as if from gradual systemic poisoning by toxin. The patients lose weight, become pale and anæmic, have no appetite, the tongue is dry and coated, and they gradually sink away.

Malignant Cases: There are certain cases of diphtheria, both in children and in adults, which run an especially malignant course. Within twenty-four hours the tonsils, palate, and lateral portions of the pharynx are covered with thick membrane and are enormously swollen, the breath is sweetish, the saliva dribbles from the mouth, the glands of the neck and their surroundings tissues are greatly swollen. The temperature is frequently but slightly elevated or it may be subnormal. The heart's action is rapid and feeble or it may be very slow and irregular. Danger of heart failure is always present. The intellect, at first clear, becomes cloudy. Within from three to five days the most robust die.

Another class of malignant cases are the so-called septic cases. The amount of local swelling and exudate on the tonsils and palate may not be very extensive, but it is of a dirty, gangrenous appearance. If the nostrils are invaded, there is a bad-smelling, thin discharge.

The temperature runs a high, irregular course, from 103° to 106° F. The tongue is dry and coated and the appetite is poor. The glands of the neck are moderately or greatly swollen. The extremities are cool, the pulse is rapid and feeble. Pneumonia or suppuration of the middle ear frequently develops. With an irregular high temperature the children become more and more apathetic until death usually supervenes.

Laryngeal Diphtheria.—The symptoms in laryngeal diphtheria differ somewhat according as to whether the process is a primary one or is an extension of a pharyngeal diphtheria to the larynx. In the latter case laryngeal symptoms are added to those already present.

In laryngeal diphtheria the symptoms are those due both to the absorption of the poison of diphtheria and to the mechanical obstruction of the larynx. The obstruction occurs more quickly in children than in adults.

The symptoms may develop slowly; the child complains of a sore throat, of a little hoarseness, has loss of appetite and slight fever. There may be a dry, hard cough. In some, within from twelve to twenty-four hours the hoarseness becomes marked, the breathing is somewhat obstructed, the temperature reaches 100° to 103° F., and the child is restless. Soon, unless relief is given or the process subsides, the symptoms of laryngeal obstruction are fully developed. The respiration is noisy; inspiration and expiration are labored and prolonged. Cyanosis is developed, and there is marked recession of the soft parts of the chest in the epigastric and jugular regions. The accessory muscles of respiration are called into action and the chest is held expanded. In spite of every exertion inspiration and expiration are insufficient.

At short intervals the child will sink back as if exhausted, the breathing is feebler, and for a moment or two the child dozes, only to awaken again to struggle for air. It throws itself about the bed, lies first on one side, then on the other. Until cyanosis is marked the intellect may be clear. Frequent desire to urinate is manifested, which adds to the distress of the child. As the obstruction increases attacks of almost complete suffocation take place; the child struggles violently for air, sitting up and using all its powers. After a time respiration may become freer, and the child sinks back only to have renewed spasms later. Sooner or later it becomes exhausted; the breathing becomes more and more feeble; the extremities are cold and the skin is of cadaveric hue. Death follows from an attack of suffocation or slowly by asthenia. The duration of life in fatal cases is usually from two to seven days when operative relief is not given.

In purely laryngeal cases, when operative relief is not given and death results early, the temperature frequently remains but little elevated, although in a few it may reach 103°–104° F. If, on the other hand, the lungs are involved, the temperature is, as a rule, elevated to 102° or 104°, or exceptionally to 106° F.

After intubation or tracheotomy the temperature frequently rises, in the more severe cases, within twelve hours to 102°–104° F. When operative relief is attained the breathing becomes natural, mucus and shreds of membrane are coughed out, and the child sinks back to sleep. In a portion of the cases the relief is permanent, and the patient progresses uninterruptedly to recovery. In others the symptoms of obstruction again appear, while in still others a secondary pneumonia develops to delay convalescence or cause death.

Symptoms of Diphtheria in Detail.—General Condition. There are a moderate number of cases having very limited patches of pseudo-membrane in which no appreciable symptoms of constitutional poisoning show themselves. They are mostly discovered because of their association with more marked cases. Even mild cases show loss of appetite and of the desire for work or play. They become more or less pale and anæmic. The more grave cases soon exhibit severe constitutional effects. They soon have marked prostration, are restless or apathetic, or both by turns. If they live long enough, they become emaciated. The sleep is uneasy. In septic cases mild delirium or stupor may develop. These cases give the impression of being very dangerously ill..

Temperature. The cases differ greatly. Many, both mild and severe, begin with a temperature of from 102° to 104° F. In the great majority the fever subsides, and even in the most severe uncomplicated cases the temperature is apt to range from 98° to 101° after the first forty-eight hours. Some, severe from the start, have a normal or even subnormal temperature.

A certain proportion of septic cases, and all having a complicating pneumonia, develop a high temperature. Other complications, such as otitis or the development of an abscess, will cause elevation of temperature.

A rise of temperature to 103°–104° F., in a case of laryngeal diphtheria, indicates usually a beginning bronchitis or pneumonia.

Nervous System. In the mild cases, except for a certain amount of apathy, no symptoms are present; in the more severe, there may be also observed the general symptoms of mild delirium, restlessness, and rarely convulsions; also apathy and stupor in the severest cases.

Circulatory Apparatus. In mild cases the pulse is frequent, and perhaps slightly irregular. In bad cases it may be very frequent, 120 to 160, and weak. The force of the heart apex beat is diminished and the sounds are indistinct. After the third or fourth day the rapid pulse may suddenly become markedly slowed. From 120 it may fall as low as from 45 to 50. It is irregular and varies in force. This is an extremely grave symptom. After from twenty-four to forty-eight hours, if the patient lives, the pulse is apt again to become rapid and feeble, and so remain until death. After the first days there is present the danger of sudden heart failure. The pulse may become weak or rapid or more rarely slow while the extremities become cold and there supervene in a few hours all the signs of collapse.

Digestive System. In the mildest cases there is little digestive disturbance, but in those of any severity loss of appetite is noted. In the worst toxic cases no food at all may be retained. The bowels are not, as a rule, affected.

The Kidneys. In the mildest cases, usually, no albumin is found in the urine, but exceptionally, after the third or fourth day, it may appear. In the more severe cases casts, kidney detritus, and large quantities of albumin are usually present. In the worst cases partial or total suppression of urine is apt to occur. These may later develop uræmic symptoms. Dropsy is not apt to occur and the prognosis is better than in nephritis following scarlet fever.

Lymph Glands. The lymphatic glands in the neck are usually somewhat enlarged. In the more septic cases they may become enormously swollen. Suppuration is rather infrequent.

Skin. A small percentage of cases develop a general erythema, which may resemble scarlet fever or measles. An urticaria may also appear. In severe and septic cases hemorrhages occur in the skin as well as in the mucous membranes.

Joints. The joints, except in septic cases, are very seldom affected in diphtheria.

COMPLICATIONS.—*Pneumonia.*—The most feared complication of laryngeal diphtheria is broncho-pneumonia. In pharyngeal diphtheria it occurs but seldom. It may develop within twenty-four hours or it may not occur till convalescence is established. In these a little fever remains, and the lungs give the signs of a moderate bronchitis. The temperature then slowly or quickly rises and the respirations become more rapid. Physical examination shows beginning broncho-pneumonia, perhaps in one or both lower lobes behind, or, again, in disseminated areas throughout both lungs. In these cases the pneumonia is apt to run a subacute but progressive course. After from one to three weeks the child succumbs to exhaustion.

Heart Failure.—From the beginning of the separation of the membrane until well into the fifth week all severe cases are in danger of heart failure. When this symptom is threatening, the patient is pale and the pulse is small and irregular. It is usually rapid and weak or very slow and irregular, 40 to 50. The extremities are cold. The mind remains clear and anxious. The attack may pass off or the pulse may be lost; the patient loses consciousness and death comes gradually. Others, apparently well, suddenly become unconscious, and die almost instantaneously of heart failure.

Paralysis.—This is one of the most characteristic symptoms of diphtheria. Frequently with the final separation of the membrane, but also often after the lapse of weeks, paralysis develops in the muscles of the soft palate, less frequently in those of deglutition, of the eye, of the respiratory organs, or finally of groups of muscles throughout the body. When the palate is affected speech is nasal and fluids regurgitate into the nostrils. When the muscles of accommodation are affected, the child cannot read and the pupils do not react. When the voluntary muscles in general are affected the patient may be completely helpless. As a rule, complete recovery takes place within from three to eight weeks, but in the worst cases marked atrophy occurs and months elapse before recovery takes place.

Relapses.—In a small number of cases, after partial or complete disappearance of the membrane, a slight recurrence results. With the exudate's appearance the temperature may rise and the glands of the neck become swollen. As a rule, the lesions clear up in a few days. The lymphatic glands may remain slightly enlarged for weeks or months. The only cases in which a relapse is serious are the laryngeal ones. A relapse may occur as late as during the fourth week.

DIAGNOSIS.—In deciding whether a doubtful case is one of diphtheria or not it is necessary to take into account whether the patient has been exposed to diphtheria, to scarlet fever, or to other infectious diseases.

If in any case exposure to diphtheria is known to have occurred, even a slightly suspicious sore throat must be regarded as probably a mild diphtheria. If, on the other hand, no cases of diphtheria have been known to exist in the neighborhood, even cases of a very suspicious nature would probably not be diphtheria.

In judging from the appearance and symptoms of a case one must first acknowledge that there are certain mild exudative inflammations of the throat belonging both to diphtheria and to pseudo-diphtheria which appear exactly alike, and have similar symptoms and similar duration. It is even possible to examine two cases, knowing that one is surely diphtheria and the other surely is not, and yet be unable to determine which is true diphtheria and which is pseudo-diphtheria. It is not meant to imply that a case is one of true diphtheria simply because the diphtheria bacilli are present, but rather that the doubtful cases not only have the bacilli present in the exudate, but are capable of giving true characteristic diphtheria to others, or later developing it themselves; and that those in whose throats no diphtheria bacilli exist can under no conditions give true characteristic diphtheria to others or develop it themselves. It is indeed true, as a rule, that cases presenting the appearance of ordinary follicular tonsillitis in adults are not diphtheria. It is also true that now and then a case having this appearance is one of diphtheria, and almost every physician has seen such cases from time to time in households infected with diphtheria. On the other hand, in small children mild diphtheria very frequently occurs with the semblance of ordinary follicular tonsillitis, and in large cities where diphtheria is prevalent all such cases must be regarded as more or less suspicious.

Appearances Characteristic of Diphtheria.—The presence of irregular-shaped patches of adherent grayish or yellowish-gray pseudo-membrane on some other portions than the tonsils is, as a rule, an indication of the activity of the diphtheria bacilli. Restricted to the tonsils alone their presence is less certain.

Occasionally, in scarlatinal angina or in severe phlegmonous sore throats, patches of exudate may appear on the uvula or borders of the faucial pillars, and still the case may not be due to the diphtheria bacilli; these are, however, exceptional. Thick, grayish pseudo-membranes which cover large portions of the tonsils, soft palate, and nostrils are almost invariably the lesions produced by diphtheria bacilli.

The very great majority of cases of pseudo-membranous or exudative laryngitis, in the coast cities at least, whether an exudate is present in the pharynx or not, are due to the diphtheria bacilli. Cases in which no exudate is apparent and those in which the laryngeal obstruction is sudden and the spasmodic element is marked, are, however, frequently due to the activity of other bacteria. Nearly all membranous affections of the nose are true diphtheria. When the membrane is limited to the nose the symptoms are, as a rule, very slight; but when the naso-pharynx is involved the symptoms are usually grave. Usually a small area of inflammation indicates a slight or moderate severity, and an extensive area a severe infection.

Most cases of pseudo-membranes and exudates entirely confined to portions of the tonsils in adults are not due to the diphtheria bacilli, although a few cases presenting these symptoms are. The more complete the involvement of the tonsils the more apt the case is to be due to them. Cases presenting the appearances found in scarlet fever, in which a thin, grayish membrane lines the borders of the uvula and faucial pillars, are rarely diphtheritic. As a rule, pseudo-membranous inflammations complicating scarlet fever, syphilis, and other infectious diseases are due to the activity of the pathogenic cocci and other bacteria induced by the inflamed condition of the mucous membranes due to the scarlatinal or other poison. But from time to time such cases, if they have been exposed to diphtheria, may be complicated by it, and in some epidemics mixed infection is common.

The Exudate due to the Diphtheria Bacilli Contrasted with that due to Other Bacteria.—As a rule, the exudate in diphtheria is firmly incorporated with the underlying mucous membrane, and cannot—except perhaps during convalescence—be removed without leaving a bleeding surface. The tissues surrounding the exudate are more or less inflamed and swollen. Where other bacteria produce the irritant the exudate, except in the cases due to the bacillus described by Vincent, is usually loosely attached, collected in small masses, and easily removable. Exceptions, however, occur in both these diseases, so that in true diphtheria the exudate may be easily removed, and in lesions due to other bacteria the exudate may be firmly adherent.

Paralysis.—Paralysis following a pseudo-membranous inflammation is an almost positive indication that the case was one of diphtheria, although slight paralysis has followed in a very few cases in which careful cultures revealed no diphtheria bacilli. These, if not true diphtheria, must be considered very exceptional cases.

Bacteriological Diagnosis.—From the above it is apparent that fully developed characteristic cases of diphtheria are readily diagnosticated, but that many of the less marked, or at an early period undeveloped, cases are difficult to differentiate the one from the other. In these cases cultures are of the utmost value, since they enable us to isolate those in which the bacilli are found, and to give preventive injections of antitoxin to both the sick and those in contact with them, if this has not already been done. As a rule, cultures do not give us as much information as to the gravity of the case as do the clinical appearances, for by the end of from twenty-four to forty-eight hours the extent of the disease is usually easy of determination. The reported absence of bacilli in a culture must be given weight in proportion to the skill with which the culture was made, the suitableness of the media, and the knowledge and experience of the one who examined it.

Diphtheria does not occur without the presence of the diphtheria bacilli; but there have been many cases of diphtheria in which for one or another reason no bacilli were found in the cultures by the examiner. In many of these cases later cultures revealed them. In a convalescent case the absence of bacilli in any one culture indicates that there are certainly not many bacilli left in the throat. Only repeated cultures can prove their total absence.

PROGNOSIS.—Diphtheria is one of the most difficult of diseases in which to make a prognosis. A case which in the first twenty-four hours seems mild may steadily increase in extent and severity until it ends fatally. A case seemingly convalescent may suddenly develop heart paralysis. Laryngeal diphtheria is especially apt to be complicated by pneumonia.

In the smaller cities epidemics vary greatly in their severity from year to year. In the largest cities, however, there are practically always a number of epidemics going on all the time, and the average severity of the whole city does not vary so much. Age has a very marked influence on mortality.

The special dangers to be feared in diphtheria are the invasion of the larynx, the development of bronchopneumonia, serious paralysis, especially of the heart and respiratory muscles, sepsis, and nephritis.

The following division of the cases of true diphtheria, based on the extent, character, and location of the pseudo-membrane or exudate, after sufficient time has elapsed for the development of the local lesions, has seemed to me to be of considerable value in prognosis:

1. Cases in which the pseudo-membranes are very extensive, thick, and firmly incorporated with the underlying swollen mucous membrane. In these the constitutional symptoms are marked, the mortality at all ages is large, and the danger of paralysis great.
2. Cases in which the development of the pseudo-membranes is largely confined to the larynx and bronchi. This form occurs mostly in young children, is very fatal at all ages, and apt to be complicated by bronchitis or pneumonia.
3. Cases in which the pseudo-membrane is moderate in amount, involving the tonsils and irregular portions of the uvula and soft palate. These often have marked constitutional and local symptoms for a few days, but nearly always recover, except in very young children.
4. Cases in which the pseudo-membrane or exudate is confined to the tonsils. These resemble those in the third division, but the symptoms are less marked. They all recover unless complications exist.
5. Cases in which very little or no exudate is ever present, the mucous membrane being simply slightly swollen and hyperæmic. These have usually slight symptoms and recover, but are important to diagnose, as they may infect others.
6. Cases of pseudo-membranes confined throughout their course to the nose. These occur chiefly in young children. The constitutional symptoms are slight, and all so far recorded have recovered. These cases are seldom met with.
7. Exudates or pseudo-membranes confined to the eyelids, skin, rectal and vaginal mucous membranes. The cases confined to the first two locations, as a rule, present few constitutional symptoms if the throat is unaffected. When the rectum and vagina are attacked, the severity of the symptoms will depend on the extent of the lesions.

TREATMENT.—*Prophylaxis.*—The patient ill with diphtheria is to be isolated, so far as circumstances permit. Wherever possible a separate room should be provided. Those who care for the sick should wear a special outer garment. Before leaving the room this gown should be removed and the hands carefully washed and rinsed with an antiseptic solution.

The patient should, when old enough, expectorate into some receptacle containing a disinfectant. Everything soiled by the mouth discharges should be disinfected by soaking in some disinfectant solution, by boiling, or by burning. The throat secretions are probably dangerous until at least three weeks after the beginning of the attack and possibly for longer periods.

Wherever possible the probable disappearance of the diphtheria bacilli should be established by the bacteriological examination of cultures. At the conclusion of the illness the bedding and, where possible, the carpets should be disinfected by steam, and the furniture, floor, and walls wiped off with a 1 to 500 solution of bichloride of mercury. Finally, it is well to disinfect the surfaces of the walls, furniture, and hangings in the patient's room by means of formaldehyde gas.

The disposal of the healthy members of an infected family is a matter of great importance. They frequently have already become infected before the first case is diagnosticated, and, if sent away, they may carry the disease to the children of the families which they visit. It is wise, therefore, to keep them at home if they have been exposed to the one taken sick. All those who have been exposed or expect to be exposed to the contagion should receive a moderate injection of antitoxin as a preventive, 200 to 500 units according to age. As a prophylactic it is well to gargle the throat frequently and cleanse the nostrils with some mild cleansing solution, such as Dobell's, or a weak disinfectant, such as 1 to 10,000 aqueous solution of bichloride of mercury. An immunization dose of antitoxin, together with the frequent cleansing of the throat, will practically insure immunity from diphtheria for at least two weeks. If the danger still persists a second injection of antitoxin is given.

Local Treatment.—If one could destroy all the diphtheria bacilli in the parts infected by local disinfection, the disease might theoretically at least be at once aborted and its extension to distant parts prevented.

Many clinicians of great experience in the treatment of diphtheria have advised various methods to accomplish this desired result, such as the direct application of nitrate of silver or carbolic acid; but personally I believe that their success must always be limited, and for the following reasons: The diphtheria bacilli are not limited to the exact spot where the pseudo-membrane has developed. They are present in the throat secretions, bathing all parts of the pharynx and tonsils before even the local lesions are manifest. Lying thus in the crypts and recesses of the parts, they cannot all be reached and killed by such antiseptic fluids as we attempt to apply to them. It is also true that only in the mildest cases are the lesions wholly accessible to local treatment.

Some years ago a series of experiments were carried out under my supervision by Drs. White and Somerset, the resident physicians of the New York Hospital for Contagious Diseases, to test the comparative value of irrigating the nose and throat with simple cleansing solutions and with disinfectants (1 to 4,000 bichloride of mercury and five- to ten-volume solutions of peroxide of hydrogen). After a fairly thorough trial it was very difficult to see more than a trifling advantage in the use of antiseptic solutions.

If we attempt to kill the bacteria in the accessible lesions by caustics or the actual cautery, we are apt to injure the tissues without killing all of the bacteria, thus doing probably more harm than good. I believe, therefore, that we should not use any treatment which will irritate or lacerate the mucous membrane. I believe that no swab should be used in making applications to the mucous membrane unless it is done by the physician or by a trained nurse, and only then with the greatest care. Personally I prefer to trust to irrigation. For the nostrils I prefer a solution of one teaspoonful of salt to one pint of tepid water. This is best applied by means of a fountain syringe, but a small glass syringe with a rubber tip answers quite well. If the nostrils are so firmly plugged that great pressure is needed, then an ordinary hard-rubber syringe can be used. To its point is attached a short rubber tube, ending in a bulb to fit the nostrils. The force needed may be great, but the shock is of less harm than the continued total occlusion of the nostrils with the accompanying absorption of toxin and the probable production of sepsis.

When the local lesions of diphtheria are limited to the tonsils, irrigation of the nostrils is unnecessary, but when the posterior nares are involved, the nostrils should be irrigated from three to twelve times a day. Even weak solutions of peroxide of hydrogen are often very irritating to the nasal mucous membrane. For the irrigation of the mouth and pharynx either a normal salt solution or a 1 to 10,000 bichloride of mercury or a neutral five-volume peroxide of hydrogen solution may be employed. In older children and adults gargles may be used when the tonsils only are attacked. The solutions are simply held in the throat as far back as possible and then ejected. It is impossible for most persons through gargles to reach more than the tissues anterior to the faucial pillars.

Local treatment may be combined with general medication; thus the giving internally of the diluted tincture of the chloride of iron or of the bichloride of mercury in small frequent doses has considerable local effect upon the mucous membranes of the throat and pharynx. Lime water and solutions of boric acid may also be given frequently in small amounts by the mouth for their local effect.

The irrigation of the nostrils with salt water or one-per-cent. boric-acid solution has not appeared to cause ear trouble.

General Treatment.—The air in the patient's room should be pure and kept if possible at a temperature of 70°–72° F.

The drugs suggested for the treatment of diphtheria have been numberless, but few of them have proved themselves as of use generally. With the exception of the antitoxin none of them are specific. At the New York Hospital for Contagious Diseases mild cases are given an abundance of light diet, milk, broth, eggs, etc., and a dose of 1,000 to 2,000 units of antitoxin. This and the local treatment are all they receive. More severe cases are given brandy, from half an ounce to twelve ounces, in the twenty-four hours, according to the severity of the disease and the amount of prostration and the weakness of the heart action. In these severe cases and in any in which paralysis threatens, strychnine is given three times a day in doses of gr. $\frac{1}{100}$ to $\frac{1}{80}$. Where necessary, cardiac tonics such as caffeine and digitalis are employed. As the patients begin to convalesce they are given some preparation of iron as a tonic if they show much anæmia.

The antipyretics are to be avoided, because of their depressant effect, and also because the temperature is, as a rule, not seriously high in diphtheria.

The tincture of the chloride of iron in moderate and frequent doses is thought by many to be of great benefit, both locally and for its tonic effect, though if it causes nausea or vomiting it should be stopped. Jacobi advises up to ʒ i. each day for an infant, and for a child three years old twice that amount. Large doses do not appear to have any more beneficial effect than small, and are more apt to cause irritation of the stomach. The internal administration of bichloride of mercury, gr. $\frac{1}{48}$ to $\frac{1}{12}$ daily, in divided doses, has not seemed to me to be of any other than local value, though thought highly of by some. Good observers advocate small to moderate doses of quinine. I myself have had but little experience with its use.

Whenever paralysis of the muscles of deglutition has become sufficiently marked to prevent the swallowing of food, it is necessary to feed through a soft-rubber tube passed through the nose into the pharynx and œsophagus. All having serious disease should remain as absolutely quiet as possible and should take their food and evacuate their bowels in a recumbent position. Bronchitis, pneumonia, otitis, nephritis, and other diseases complicating diphtheria are treated as if they were primary diseases.

Treatment of Laryngeal Diphtheria.—For the relief of obstruction in laryngeal diphtheria there are the inhalation of the fumes of subliming calomel, the inhalation of warm steam with or without lime or other additions, the application of warmth or cold over the larynx, and the use of medicines internally, especially those causing nausea or vomiting.

The first two are the most important means of combating the beginning laryngeal obstruction.

Calomel Fumigation. This was first advocated by Corbin in 1881, and has since been extensively used. The inhalation of subliming calomel does not, as some claim, destroy the diphtheria bacilli, but it does often greatly relieve the obstruction with its accompanying symptoms. This so often follows each employment of it that there seems to be no doubt of its action. It does not, however, afford relief in all cases, even when used very early.

The method of using calomel fumigation varies with the apparatus at hand. The child should be put in an improvised tent so as to confine the fumes sufficiently to fill the tent with a rather dense white smoke. From ten to twenty grains can be thrown on a few live coals placed on a shovel and held under the tent while it sublimes, or a lump of live coal may be put in an iron or earthenware vessel and over it a strip of iron or an iron spoon upon which the calomel is placed. In the larger cities a suitable apparatus can be bought ready for use, which is, of course, more convenient.

Steam. The inhalation of warm steam is certainly at times of great benefit. To the water may be added equal parts of lime water, or to each pint one or two teaspoonfuls of compound tincture of benzoin. The warm, damp vapor is the chief thing. The steam should be inhaled as warm as possible, and the patient should be protected from the dampness by a covering of oil-muslin, or a thin blanket.

If in a strong child the laryngeal symptoms increase so that it seems as if intubation will soon become necessary, the effect of vomiting may be tried. For this purpose a dose of fl. ℥ ss.–i. of syrup of ipecac should be given every ten minutes until effective. Instead of ipecac, tartar emetic or the yellow subsulphate of mercury, gr. ij.–v. to a child of two years, and repeated, may be given. If an attack of vomiting does not give appreciable relief, it is not well to repeat it, as it exhausts the child and offers but slight hope of benefit. If a child is much prostrated, it is unwise to resort to emetics at all.

Intubation and Tracheotomy. If in spite of treatment the laryngeal stenosis advances so far that actual obstruction to breathing is marked and increasing, we must resort to intubation or tracheotomy.

By one or the other of the means we overcome the obstruction to the entrance of air through the larynx, and thus prevent suffocation, unless the membrane is too extensive below the end of the tube We also aid the expulsion of mucus and portions of membrane through the opening formed by the tube. The insertion of the tube does not, of course, limit the extension of the disease or prevent complications. The apparent improvement due to the removal of the obstacle to respiration will therefore only be permanent when the disease itself yields to treatment.

The time at which intubation should be performed is a question of the greatest importance.

The insertion of a tube into the larynx is not wholly a matter of indifference even in trained hands. More or less abrasion of the swollen and inflamed laryngeal mucous membrane may be caused by its insertion, and its presence for several days is very likely to cause a superficial ulceration, either where its lower end impinges on the trachea or where its sides cause pressure.

On the other hand, so soon as the laryngeal stenosis becomes so marked that the person struggles for air, and in spite of the struggle sufficient aeration of the blood does not take place, that condition is a great detriment to the condition of the child long before any actual suffocation is impending.

In spite, then, of the possible injury to the larynx of the insertion and retention of the tube, we should not wait too long and thus allow a greater injury to occur.

If, therefore, the stenosis steadily increases and the retraction of the epigastric and jugular regions becomes decided, and cyanosis is evident, it is better not to wait longer. (See article on *Intubation.*)

Treatment of the Patient while Intubated. It is frequently the custom to raise slightly the foot of the bed on which the child lies, and it is always well to keep the child prostrate if possible.

A matter of vital importance is the feeding of the child, so that food will not pass down the tube. This is first attempted with the child lying down, with the head depressed below the rest of the body. If the child does not take fluid nourishment in this way, it is allowed to drink in the natural manner. If it is impossible to feed the child by either of these means, it must be fed by a stomach tube passed through the nose into the stomach. For a child of one or two years the tube should be the size of a No. 6 catheter; for a child of three to four years, a No. 8 catheter. Some physicians prefer, instead of a fluid diet, food which is of greater consistence or even entirely solid. At the Willard Parker Hospital for Contagious Diseases, however, fluid diet is, as a rule, preferred.

Extraction of the Tube. At any time after the insertion of the tube it may be coughed up, or it may become obstructed by membrane either blocking the tube or filling up the trachea below. Whenever the tube becomes obstructed it must be instantly removed. In those cases, however, in which the tube is neither coughed up nor obstructed it is found best to leave it in for such a period that five to seven days have elapsed from the time of the beginning stenosis. If the tube is removed earlier, it will usually have to be replaced, with the danger always of creating slight abrasions or injuries of the larynx.

Serum Therapy. The use of diphtheria antitoxin has passed the experimental stage and its use is now as firmly established as is that of vaccine as a preventive of smallpox. Its action seems to be to neutralize the diphtheria poison produced by the diphtheria bacillus and thus to render it inert and powerless to do injury. Whether this is the entire explanation of its action or not, it is most important to realize that both in animals purposely infected with diphtheria and in human beings ill with the disease the beneficial effects of antitoxin are most evident when it is given very early in the disease, before marked tissue degeneration has occurred.

Statistics gathered from all over the world are in accord, that the cases injected on the first day show the least, those on the second somewhat more, and those on the later days the greatest mortality. The chemical nature of antitoxin has already been considered under *Antitoxins* in Vol. I. As the results obtained with the antitoxin treatment have been so much in evidence in the journals, I will give here only a few figures from Krönlein (Zurich), quoted from the article on diphtheria by Jacobi in the "Twentieth Century Practice of Medicine." These are in accord with my personal observations in private practice, but rather more favorable than in hospital practice.

		Mortality, per cent.
Preantitoxin period, total cases	1,336	39.3
Operative cases	662	66.1
Antitoxin period, total cases	437	12.5
Operative cases	17	36.0

When antitoxin is given in sufficient amount shortly after the onset of the first symptoms the mortality is less than four per cent. It is rare for an uncomplicated case of diphtheria thus treated to die.

The immediate results which follow an injection of antitoxin in a case of diphtheria differ according to the period of the disease at which it was given and the characteristics of the case. This is due to the fact that while injection of sufficient antitoxin prevents any further effect of the diphtheria toxin, it will not lessen the toxic effects of the poisons produced by the other bacteria nor will it stop the progressive degeneration of cells already so injured that recuperation is impossible.

When antitoxin is administered early in pharyngeal, tonsillar, and nasal diphtheria the results are usually striking; improvement sets in quickly, the temperature drops within from three to twelve hours, the local inflammation abates, and the membranes and exudate soon loosen. The local disease does not spread to adjacent or distant portions of the mucous membranes. Except for slight prostration and anæmia the patient is frequently well in from two to three days.

When antitoxin is administered after the full development of the diphtheria the results are much less striking, so that we often are in doubt as to whether any actual results have been obtained. Undoubtedly many of these cases run a milder course than without antitoxin.

In laryngeal diphtheria it is difficult to be certain of the immediate effects in individual cases. When we examine a case we cannot as a rule tell the amount of larynx, trachea, and lung involved, and so are ignorant of the real severity and extent of the disease.

More cases of those receiving antitoxin early recover without having needed intubation than formerly, and those needing intubation are on the average able to have the tube removed earlier than before. Upon the bronchitis and broncho-pneumonia which develop in some, antitoxin has little or no effect.

Ill Effects of Antitoxin Serum.—A small percentage of the cases have a slight rise of temperature immediately after an injection. In a very few cases abscesses develop at the seat of the injection. This is a preventable accident.

Rashes.—These are peculiar to the serum injections. They are undoubtedly partly due to the horse serum, not altogether to the antitoxin. They occur in from five to twenty per cent. of the cases, according to the characteristics of the serum. The eruption may be limited to the point of injection, or may more or less completely cover the whole body. It most often appears as an urticaria, but may very closely resemble scarlet fever or more rarely measles. It usually develops between the seventh and fifteenth days, but may occur as early as on the second day. In some cases all the forms may be united in one person. Following the eruption, desquamation may occur. In about one-fifth of the cases there is a rise in temperature of 2°–4° F. This lasts for from one to three days. In a small percentage of cases there is accompanying the rash tenderness over the joints of the extremities. These pains last, as a rule, for from one to four days.

There have been a few cases reported in which the joint lesions persisted for several weeks. The urticaria and erythema which at times accompany the rise in temperature are in certain cases very distressing, and in a person already prostrated might not be wholly without danger to the patient.

I have seen, in watching over fifteen hundred cases, no serious effects upon the heart, kidney, or nervous system which I attribute to antitoxin, with the possible exception of two cases of scarlatina complicated with diphtheria. In these two there was an almost complete suppression of the urine. This was probably due to the scarlet fever and diphtheria, and not to the antitoxin.

Dosage of Antitoxin.—From my observation of cases in both hospital and private practice, I have been led to adopt the following dosage:

	Units.	
Very mild cases	1,000–1,500	for the first dose.
Moderately severe cases	2,000–3,000	" " "
Very severe cases................	4,000–5,000	" " "
Laryngeal cases, according to their severity................	2,000–5,000	

For children under one year I should give about one-third less than for older children and adults. I believe the condition of the throat as to swelling, extent and nature of the membrane, etc., to be a better guide to antitoxin dosage than the general condition of the patient. The duration of the disease, rather than the dosage, influences the curative power of the antitoxin.

If, at the end of twelve hours after the injection, the inflammation is advancing, or if at the end of eighteen hours the inflammation has not clearly begun to subside, as shown by lessened congestion and swelling, I believe a second dose of antitoxin should be injected. In a very few cases a third dose is required at the end of from twenty-four to thirty six hours. For the broncho-pneumonia and sepsis complicating some of the worst cases antitoxin is generally of no avail. Although I cannot agree with Dr. McCollom in regard to the necessity of from 40,000 to 60,000 units in the very bad cases, nevertheless his results certainly encourage us to give all the antitoxin that we think indicated. It is better to give too much rather than too little. I think I am correct in saying that it is the opinion of the visiting physicians at the hospital that moderate doses accomplish as good results as very large ones.

William H. Park.

DIPLOPIA (from *διπλόος*, double, and *ὤψ*, eye) is the double vision resulting from the formation of two images of the same object upon non corresponding parts of the retinæ of the two eyes. Strictly speaking, in every act of binocular vision this condition obtains in the case of all objects which are either nearer or more distant than the point of intersection of the visual axes, although, in these cases, the incongruity of the two images is ordinarily recognized as the expression of a difference in distance (stereoscopic vision) rather than as double vision. In viewing near objects against a distant background, the details of the background, as seen by either eye singly, are in a measure effaced as a result of the exercise of the accommodation required for distinct vision at the shorter distance; and, in binocular vision, the incongruity of the two retinal images of the background operates still further to prevent their special recognition. Again, in looking at distant objects, as at the details of a landscape, through a window screen of gauze, we may be almost or even quite unconscious of the presence of the screen, although, by a voluntary exercise of the accommodation and the convergence, we may see its meshes distinctly, and may then become conscious of the fact that the finer details of the landscape, as seen through it, have become indistinct, and that some of its more conspicuous features appear doubled. In fact, we unconsciously concentrate the attention upon objects at about the distance for which the two eyes are accommodated and for which their axes are converged, and so come to disregard the less perfectly defined and incongruous images of nearer or of more distant objects.

The fact of the formation of incongruous retinal images of objects either nearer or more distant than the point of intersection of the visual axes, may be demonstrated by holding a small object, such as a pencil, in a vertical position at a distance of a foot or two from the face and at about the same distance from a vertical bar of the window sash; if we look with the two eyes at the pencil, it will be seen single between two images of the sash bar; if we look with the two eyes at the sash bar, it will be seen single between two images of the pencil. That this seeing of one or the other of the objects doubled is a result of simultaneous vision with the two eyes is shown by the fact that one of the images disappears on covering either eye.

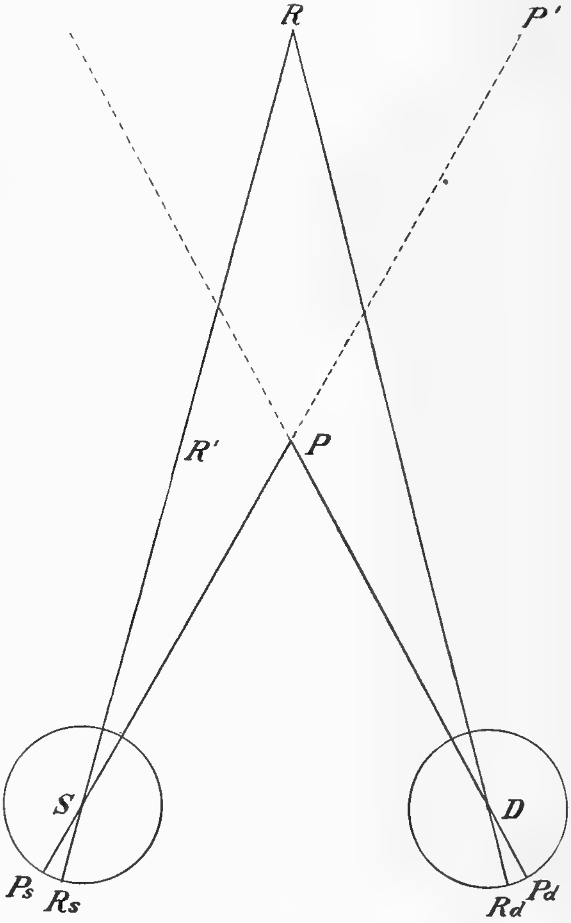

FIG. 1597.

If, directing the eyes upon the nearer object (the pencil), so that the more distant object (the sash bar) is seen doubled, we cover the right eye, we find that we shut off the right-hand image of the more distant object; similarly, covering the left eye, we shut off the left-hand image. The double vision (diplopia) is then, in this case, *homonymous*—*i.e.*, the image to the right is seen by the right eye, and the image to the left by the left eye. If now, directing the eyes upon the more distant object (the sash bar), so that the nearer object (the pencil) is seen doubled, we cover the right eye, we shut off the left-hand image of the pencil, and, covering the left eye, we shut off the right-hand image; the diplopia is, in this case, *heteronymous*, or *crossed*.

Let *D* and *S* (Fig. 1597) represent the right and the left eye, respectively, and suppose that the two eyes are directed to converge upon a small near object at *P;* the two retinal images, *Pd* and *Ps*, will then be formed each at the fovea centralis of its own eye, and the object *P* will be seen single with the two eyes. If we suppose now a second and more distant object at *R*, two images of *R* will be formed, at *Rd* and *Rs* respectively, each to the inner or nasal side of the fovea. The more distant object *R* will then be seen by the right eye in the direction *Rd R*, to the right of *Pd P*, and by the left eye in the direction *Rs R*, to the left of *Ps P;* therefore doubled, and the doubling (diplopia) will be *homonymous.*

If we suppose the two eyes to be directed to converge upon the more distant object at *R*, the two retinal images, *Rd* and *Rs*, will be formed each at the fovea centralis of its own eye, and *R* will be seen single with the two eyes; but the two images of *P* will be formed, at *Pd* and *Ps* respectively, each to the outer or temporal side of the fovea. The nearer object *P* will then be seen by the right eye in the direction *Pd P*, to the left of *Rd R*, and by the left eye in the direction *Ps P*, to the right of *Rs R;* therefore doubled, and the doubling (diplopia) will be *crossed.*

The apparent direction of any visible object from the observer is ordinarily determined by the direction in which the two eyes are turned in order to see it single. When, however, only one of the eyes is directed accurately upon the object, its apparent direction is determined by that of the accurately directed eye, and the image formed on the retina of the misdirected eye is projected eccentrically, on the visual field, in a direction opposite to that in which this eye is turned. Thus in the case of an eye which deviates inward, the retinal image of the object upon which the other eye is directed is formed to the inner side of the fovea, and is projected, on the visual field, to the outer side of the object as seen by the accurately directed eye. A diplopia which is the result of *crossing* of the eyes is therefore *homonymous.* Again, when one of the eyes deviates outward, the retinal image is formed to the outer side of the fovea, and is projected to the inner side of the object as seen by the accurately directed eye. A diplopia which is the result of *divergence* of the eyes is therefore *crossed.* In the case of a vertical diplopia, the higher position of the false image indicates that the misdirected eye is turned downward, and *vice versa.* So, too, in the case of a diplopia in which a line drawn through the two images is intermediate between the horizontal and the vertical, the displacement of the false image on this oblique line is in the direction opposite to that in which the misdirected eye is turned.

Referring again to Fig. 1597, suppose the eye *D* to be directed upon an object at *R*, and the eye *S* to be turned toward a second object at *P'*, on the line *Ps P* produced. Two different retinal images, *Rd* and *Ps*, will then be formed, each at the fovea of its own eye, from which it might be expected that the two objects, *R* and *P'*, would be seen simultaneously as a composite picture. This is, however, not ordinarily the case. Either the attention is concentrated upon the object *R*, which is then seen centrally and distinctly with the eye *D* and also eccentrically and less distinctly with the eye *S*, or upon the object *P'* which is then seen centrally and distinctly with the eye *S*, and also eccentrically and less distinctly with the eye *D*. In the one case the object *R* is seen homonymously doubled, and the two images of *P'* are disregarded; in the other case the object *P'* is seen homonymously doubled, and the two images of *R* are disregarded.

Again, suppose the eye *D* to be directed upon an object at *P*, and the eye *S* to be turned toward *R'*, in the direction of *R*. In this case two different retinal images, *Pd* and *Rs*, are formed, each at the fovea of its own eye, but the attention is concentrated either upon the object *P* or upon the object *R'*, one of which is seen heteronymously doubled (crossed diplopia), and the two images of the other object are disregarded.

Diplopia may be evoked experimentally by slightly changing the direction of one of the eyes by making moderate traction upon the eyeball through the eyelid; the second image then appearing to the side of the object opposite to that toward which the axis of the eye has been turned. Diplopia may also be evoked by artificially altering the direction in which the rays of light from any object enter one of the eyes, as in looking through a thin prism held in front of one eye. If, while looking at any small object with the two eyes, we interpose a thin prism in front of either eye, so as to cover about half of the pupil, the object will be seen single with the two eyes through the uncovered half of the pupil, and doubled through the half of the pupil covered by the prism; or, by slightly varying the direction of the two eyes, so as to look either past the prism or through it, the object may be seen single or doubled, at will. When the prism is turned with its refracting edge either toward the nose or toward the temple, the resultant horizontal diplopia, whether crossed or homonymous, may be observed to drift almost immediately into single vision with the two eyes, through an unconscious change in the convergence; in other positions of the prism the diplopia persists. The apparent displacement of the object, as seen through the prism, is in the direction of the edge of the prism.

Diplopia, as an anomaly of vision, may result from any deviation from the normal relative direction of the axes of the two eyes. Such deviation may be the effect of a purely mechanical cause, as when the range of movement of one of the eyes, in some particular direction, is limited by a cicatrix of the conjunctiva, by a symblepharon, etc.; or it may be dependent on a displacement of one of the eyeballs from an orbital hemorrhage or tumor; or upon a fracture of the bony wall of the orbit impairing the lateral support of the globe, or perhaps injuring one or more of the muscles of the eye. Diplopia from such causes may be either transient or permanent; and it may be present, often in varying degree, in all positions of the eyes, or, in cases in which certain movements of the affected eye are restricted only in their extreme range, it may appear only on looking in some particular direction, and may then be prevented by avoiding such movements of the eyes by substituting for them a movement of the entire head.

Diplopia is sometimes a predominating symptom in cases of slight preponderance of either the recti interni or the recti externi muscles over their antagonists, and is then either homonymous or crossed. As the normal range of convergence of the optic axes is somewhat increased when the eyes are directed downward, and diminished when they are directed upward, a person suffering from slight insufficiency of the interni will sometimes correct the tendency to crossed diplopia by habitually carrying the head tipped a little backward; and, similarly, in the case of slight insufficiency of the externi, he may correct the tendency to homonymous diplopia by habitually bowing the head. In such cases the wearing of prismatic spectacles, with the bases of the prisms turned inward or outward according as the interni or the externi are in need of assistance, may afford perfect relief, and enable the patient to carry his head in the normal position. So, also, a slight deviation of one of the optic axes upward or downward may give rise to a vertical diplopia which may be corrected by wearing spectacles of which one of the glasses is a prism set with its base downward or upward, as may be indicated; or a pair of prisms may be given, with their bases in opposite directions, so as to divide the correction between the two eyes.

As in normal binocular vision, both eyes are directed upon the object, with the result that the two nearly identical images, falling centrally upon the two retinæ, are mentally combined in a single composite impression, so in diplopia dependent on a faulty direction of the axes of the two eyes, one to the other, the object is always fixed by one eye, the image falling centrally upon its retina and eccentrically upon the retina of the deviated eye. Of these two images, the central image, in the fixing eye, is recognized as the "true" image and is utilized in seeing the object and in estimating its direction; at the same time, the eccentric image, in the deviated eye, is recognized as a "false" image, obtruding itself more or less persistently on the vision to the confusion of the general impression. Simultaneous vision with the two eyes becomes then a hindrance rather than a help, and the sufferer learns to suppress the confusing second image, at first by covering or closing the deviated eye and later, in many cases, by ceasing to take cognizance of the confusing visual impression. Confused vision with the two eyes then gives place to single vision with the fixing eye, the deviated eye no longer contributing anything to the psychical impression, and this wholly independently of the actual acuteness of vision in either eye.

Instances of this psychical suppression of one of the two retinal images occur in different types of strabismus. Thus in strabismus, whether convergent or divergent, the patient sees, as a rule, exclusively with the straight eye, although on covering this eye he may see perfectly with the fellow eye, the previously straight eye then assuming the position of deviation. In the alternating type of strabismus, the patient is able to fix the object and see it distinctly with either eye, but receives no simultaneous impression through the other eye. In periodic strabismus there is ordinarily good binocular vision so long as the two eyes are properly directed upon the object, but this gives place to vision with a single eye whenever the second eye wanders from the true direction.

In true (concomitant) strabismus the angle of deviation of the misdirected eye is approximately constant, whatever may be the direction in which the fixing eye is turned. The position of the false image, as regards its direction and distance from the true image, remains, therefore, practically unchanged in all movements of the eyes. To suppress the false image, it would then appear to be necessary to disregard only such part of the retinal picture in the deviated eye as is formed on a definite and rather small eccentric area of the retina. That this is what actually occurs, in many cases of strabismus, is shown by the fact that the suppressed diplopia may often be made manifest by changing the relative position of the two images by looking through a prism or prisms placed before one eye or both eyes. So, also, a previously suppressed diplopia not infrequently reasserts itself as the result of the change in the position of the false image following an incomplete correction of strabismus by an operation.

The suppression of simultaneous recognition of the two images in strabismus, although complete under ordinary conditions, may, nevertheless, often be shown to be incomplete by artificially varying the conditions under which the object is viewed. Thus, in looking at the flame of a lamp, at a distance of say ten to twenty feet, the flame will ordinarily be seen single with the fixing eye; but on placing a colored glass before one of the eyes, so as to change the apparent color and brightness of the flame as seen by this eye, two differently colored images of the flame may appear.

By the use of the "glass-rod" test of Maddox, which consists in looking transversely through a cylindrical glass rod of 4 mm. or 5 mm. diameter held in front of one eye, the flame of a lamp, as seen with this eye, is drawn out into a very long bright streak at right angles to the axis of the rod. This linear streak, which is wholly unlike the image of the flame as seen by the other eye, and which also extends across an area of the retina many times larger than that occupied by the untransformed image, is often perceived simultaneously with the flame in cases in which prisms or colored glasses, whether used alone or in combination, give only a negative result. As improved by its inventor, by the substitution of several somewhat smaller parallel rods (which may be of colored glass) for the single rod, or replacing the system of rods by a disc of plain or colored glass crossed by parallel flutings, this test affords the most effective known means for bringing to light a diplopia which has become latent through the suppression of one of the two retinal images, as well as for investigating the relation of the two images, one to the other.

In paralysis or paresis of one or more of the external muscles of the eyeball, from suspended or impaired function of one of the motor nerves (third, fourth, or sixth), diplopia is from the beginning a prominent and generally a persistent symptom. In uncomplicated paralysis (or paresis) of a single muscle, deviation of the axis of the affected eye occurs only in looking in the particular direction in which the muscle is unable fully to perform its proper work, while in looking in other directions the normal relative direction of the axes of the two eyes is preserved. Binocular vision is, therefore, only occasionally disturbed by the perception of double images, and the diplopia evoked by an unsuccessful attempt to turn the eye in the direction of the paralyzed muscle may be corrected by turning the head in the same direction, and so fusing again the momentarily separated images. Furthermore, the distance by which the two images are seen separated from each other is dependent wholly upon the direction in which the eyes are turned, and is, therefore, a varying quantity; so that the false image, which is projected at different times upon different portions of the retina of the deviated eye, is constantly reasserting itself in a new position, and is, therefore, less easily disregarded than in the case (as in strabismus) in which the relation of the two images to each other is practically constant. In a later stage of the affection, however, the unopposed antagonist of the paralyzed muscle usually becomes shortened, so that some degree of doubling appears even in the most favorable positions of the eyes; but even then the diplopia remains variable in degree, and is apt to persist as an ever-recurring source of visual disturbance.

In diplopia, whether dependent on an impediment to the free mobility of one of the eyes, or upon perverted action of one of the ocular muscles, it is ordinarily the affected eye which deviates; exceptional cases occur, however, in which this eye is so much the better eye, as regards acuteness of vision, that it continues to be used, and is consequently accurately directed upon the object, while the deviation is transferred to the eye whose motility remains unimpaired. Hence, it is sometimes possible to fall into the error of attributing a defect in motility to the wrong eye, as, for instance, in a case of vertical diplopia, in which it may be difficult to decide whether one of the eyes is turned a little upward or the other a little downward, or in a case of homonymous or crossed diplopia, where we may be in doubt whether the excessive or insufficient convergence has its seat in one or the other of the eyes, or in both eyes. From a practical standpoint, however, these nicer points of diagnosis are ordinarily of minor importance, for the reason that, if the deviation is of such a nature and degree as to bring it within the power of prisms to correct it, the prisms must usually be applied to both eyes in order to obtain a sufficient refractive effect with the least disturbance from dispersion; and, similarly, in a large proportion of cases of deviation for which tenotomy may be the appropriate remedy, the requisite correction is often best attained by operating upon both eyes.

We have thus far considered diplopia as simply a doubling of the visual impression; but, in fact, the axis of the deviated eye is often not only misdirected, but also more or less rotated or twisted. Of the six muscles which move the eyeball in different directions, only two, the rectus internus and the rectus externus, effect a simple change in its direction. The other four muscles, viz., the rectus superior, the rectus inferior, the obliquus superior, and the obliquus inferior, when they act singly, cause also some degree of rotation of the axis of the eyeball, and thus give rise not only to a displacement, but also to a notable rotation of the image. Under normal conditions, the tendency to rotation from the action of the superior rectus is neutralized by an equal tendency to rotation in an opposite direction through the action of the inferior oblique; and, similarly, the rotating effect of the inferior rectus is neutralized by an opposite rotating action of the superior oblique. But when any one of these muscles is paralyzed, this correcting power is lost, and the correlated muscle is left free to exert its function of rotation. This rotation of the false image is best studied by directing the patient to look at a footrule held vertically or horizontally at a distance of from one foot to three or four feet from the face; the relation of the two images, one to the other, may then be noted for different positions of the rule. The false image will be seen turned in a direction oblique to that in which the rule is held and in which it is seen by the non-deviated eye. Diplopia with marked rotation of the false image is often a source of especially annoying and persistent visual disturbances; the rotation cannot be overcome by wearing prisms; an operation on the weakened muscle (advancement of its insertion) proves, at the best, only palliative in most cases; and the division of the tendon of the muscle which is the active cause of the combined deviation and rotation, when the eyes are turned in certain directions, will often only aggravate the trouble by giving rise to new and disturbing limitations of the movements of the eyeball in looking in other directions. The special consideration of the different positions and rotations which the false image may assume, in connection with paralysis of a particular muscle or of particular muscles, belongs properly to the subject of the disorders of the motor apparatus of the eyes.

An anomalous type of diplopia has been occasionally observed in which a false image, evoked by colored glasses or by the Maddox test, is seen at the side of the object opposite to that at which it should appear in accordance with the law of optical projection. The few instances of this anomaly which have come under the observation of the writer have been in cases of convergent strabismus which had been approximately corrected by operation, but in which some residual crossing was still to be detected by inspection of the eyes and by their change of direction in alternate distant fixation. With perfect central fixation and visual acuity scarcely below the normal, in either eye, it was impossible to elicit any evidence of simultaneous central vision with the two eyes; but on bringing a colored glass before one eye or differently colored glasses before the two eyes, or applying the Maddox test, a crossed diplopia, equivalent in degree to that which is ordinarily associated with notable ocular divergence, became manifest. In a case of convergent strabismus in a young man twenty-three years of age, with convergence in distant vision of about 6°, persisting after division of both recti interni about seven years ago, a crossed diplopia of about 15° can still be demonstrated by colored glasses and by the Maddox test. This reference of a retinal impression, made actually at the nasal side of the fovea, to a different position, at the temporal side of the fovea, has been conjecturally explained on the assumption of a possible anomaly of distribution, in the retina, of special nerve fibres directly concerned with the function of binocular vision.

Diplopia Monophthalmica, or double vision with a single eye, is a result of the formation of two images of the same object on different parts of the same retina. If we look at a candle flame through two pinholes, about 3 mm. apart, pricked in a card, the images formed by the refracting media of the eye in the two uncovered small areas will fall together on the retina only under the condition of the accurate adjustment of the eye for the distance of the object. In all other cases the two images will fall on different parts of the retina, and the object will be seen doubled. Similarly, in the somewhat rare cases of a supernumerary pupil resulting from traumatism, or perhaps from an imperfectly executed surgical operation involving the iris, the rays traversing the two pupils may either fall together, to form a single retinal image, when the eye is accurately adjusted for the distance of the object, or separately, on different parts of the retina, to form two images, when the eye is not so adjusted. The correction of the eye by an appropriate lens suffices to effect the fusion of the two images in a single image.

Double vision in a single eye may occur as a particular case of polyopia monophthalmica, in which a bright point appears broken up into a star of small bright spots, as an effect of incongruous refraction through different sectors of the crystalline lens (see Fig. 376, vol. i., p. 596). In the early stages of cataract this refractive incongruity is often both notably increased and accompanied by some degree of ametropia, so that the disc of the moon may appear as a cluster of overlapping moons. In astigmatism, the more or less completely separated images of a bright object may appear compressed into a row of images corresponding in direction to the ocular meridian of greatest ametropia; or a row of lights corresponding in direction to the ocular meridian of least ametropia may be seen as two or more parallel rows of lights. In myopic astigmatism, when the meridian of greatest refraction is vertical, the moon is often described as appearing like two overlapping moons, one above the other, and a telegraph wire or a clothes line may appear not only blurred but doubled at the two margins of the diffuse image.

A local deformation of the cornea may give rise to a second image separated more or less widely from that formed by refraction at the general corneal surface. When a diplopia from this cause is very troublesome, a considerable measure of relief may sometimes be afforded by tattooing the disturbing area of the cornea with India ink.

John Green.

DIPPEL'S ANIMAL OIL.—(*Animal Oil; Ethereal Animal Oil.*) By the dry distillation of bone, horn, and animal substances generally, an oily liquid is produced, which was formerly used in medicine under the common name of *Dippel's oil* or *Dippel's animal oil.* The oil, when purified, is a thin, colorless, or yellowish fluid, of a pungent, ethereal, and smoky flavor. It is a very composite body, containing among other things quite a number of organic bases. Physiologically it is neurotic and irritant, and has proved fatally poisonous in doses of a tablespoonful. It was formerly prescribed internally in doses of a few drops, or used externally as an irritant embrocation, clear or as an ingredient of composite liniments.

Edward Curtis.

DIPTHERYX. See *Tonka.*

DIRECTION, JUDGMENT OF.—It is proposed to consider here the judgment of direction of such objects only as are outside the body and not in contact with it.

Heat and Cold.—The direction of an object capable of producing either of these sensations can be roughly estimated by inference from the part of the skin affected, but the judgments thus made are of little importance in normal persons. In the blind, however, these sensations are much used, forming an important portion of those involved in "facial perception."

Sound.—Sound waves also offer some data for judging direction. The following account of the phenomena is taken from Wundt. The concha acts as a condenser, specially collecting those waves which come from in front. The same sound is therefore heard more intensely when coming from that direction. This fact is brought out by an experiment where the conchas are bound down and some apparatus representing them is attached to the sides of the head, with the concavity directed backward. By this device the natural conditions are reversed, and sounds coming from behind are thus heard more distinctly and are then wrongly judged to come from in front. It has been suggested that the tactile sensibility of the concha, re-enforced by the hairs on it, may, in the case of loud sounds, be a means of indicating the direction. But this explanation is not sufficient, for in the case of faint sounds discriminations between "right" and "left" can be more easily made than between "in front" and "behind," while with sounds coming from in front it is possible, to a certain extent, to determine the angle formed by the line of the sound waves with the median vertical plane of the body. Since the closing of one ear destroys this localization of direction, the latter must be considered as a function of binaural audition. When certain partial tones are intensified by the resonance in the external meatus, then the relative intensity of the sensation in the two ears has an influence. It is probably due to the latter cause that noises in which, as a rule, high resonating overtones exist, are more exactly localized than simple notes. In the studies on the monaural localization of sound made by Angell and Fite, it was found that the judgment of direction was very accurate in persons depending on one ear only, and depended largely on the quality of the sound coming from different directions. It is possible that certain muscular and tactile sensations should also be here included. Ed. Weber conjectured that the tympanum felt its own vibrations. It better accords with the results of other experiments, however, to consider that the action of the tensor tympani muscle, by its involuntary accommodation to sounds of different intensities, thus accompanies auditory impressions with muscle sensations of varying strengths. In cases of auditory hyperæsthesia, affecting one ear alone, errors of judgment may arise, owing to the fact that a sound coming from the side *opposite* to the hyperæsthesia may nevertheless cause a so much stronger sensation that the patient completely misjudges its direction.

Light.—Sight is the sense through which the chief judgments of direction are made. In all cases the direction of an object is represented by a line joining the body with the object, and objects on that line or its continuation are considered to have identical directions. The phenomena are first to be considered for one eye alone, the field of vision being stationary. When the image falls on a part of the retina other than the fovea, the eye must be turned in order to bring the image on that point, and for this purpose it must be moved by its muscles. In performing such a muscular movement there are at least two sensations which may be recognized: the innervation feeling and the tension of the muscles. When the eyeball is pulled to one side by the hand, objects in the field of vision appear to move, and the eye to remain quiet; at the same time, pulling the eye changes the tension of the muscles; nevertheless, neither the movement of the eye by a means other than the contraction of its own muscles, nor the tension of the muscles due to the same cause is recognized as a motion of the eye, and so objects appear to move in a direction opposite to that in which the eye is pulled.

In patients having the musculi recti paralyzed, an attempt to contract a rectus is followed by an apparent motion of objects in a direction opposite to that in which it is willed to move the eye. In this case there is present neither the contraction of the muscle nor any result of the exertion, but merely the innervation feeling; yet, from this arises a subjective sensation of motion. Since the innervation feeling can produce this result, it is argued that our judgment of the direction of an object seen is based on the remembrance of the innervation feeling necessary to bring the eye into such a position that the image shall fall on the fovea.

The only result of the innervation impulse which we plainly recognize in the eye is the altered position of objects in the field of vision. This alteration, bringing with it a variation in the position of the image, can be shown to act as a control on innervation efforts.

If a prism be put before the eye so as to cause the rays from a given object to fall on a new part of the retina—the object, for example, having thus been apparently moved to the left—and then, the eyes being closed, if the hand is stretched in the supposed direction, it will fail to touch the object, passing by it to the left. On touching the object, however, with the eyes open, and associating thus the new position of the image with fresh tactile sensations, a new combination is developed by which it can be inferred from the position of the retinal image where the hand must be placed to touch the object.

When two eyes are used the conditions are somewhat complicated, for one eye influences the judgments derived from the other. Helmholtz gives the following illustration: When one eye is closed, both axes being kept parallel, and first a distant then a very near object is fixated, both having identical directions, no change occurs in their apparent position in the field so long as the eye is simply focussed from one to the other. If, however, the near object be fixated and the closed eye be now converged so as to occupy the position necessary to fixate it if it were open, a marked apparent motion takes place in the distant object in such a way that, if we consider the left eye as the one open during the experiment, the distant object moves from right to left. On again making the axes parallel, it resumes its former position. The sense of direction, as derived from one eye, must accordingly be considered modifiable by the other eye, even though the latter remains closed. In an analogous way the judgment of horizontal and vertical lines is found to be influenced by the motions of the closed eye. For instance, with the axes parallel, one eye being closed, a thread forming the diameter of a short circular tube, when judged to be vertical or horizontal, is found to be really so, though by putting the head in different positions during the experiment the retinal horizon of the observing eye may, in certain of these positions, make an angle of even ten degrees with the true horizon. When, however, the previously parallel axes are converged, and the individual fixates a point on the thread, the line which was previously horizontal is now seen to undergo apparent rotation of such a nature that it corresponds with the rotation of the retinal horizon of the closed eye. Suppose in this case the right eye to be open, then on converging the left (closed) eye the right end of the thread apparently sinks while the left rises. The position of the eyeballs is found to be in part under the reflex control of impulses from the semicircular canals, and for this reason all judgments modified by the position of the eyeballs tend to be also modified by changes in the position of the head.

In the section on judgment of direction Helmholtz treats of a number of cases in which the objects viewed are in motion, for example, falling water. One who has watched a waterfall for a time notices, on looking at the bank, that objects there appear to move in a direction opposite to that of the water. The explanation offered by Helmholtz is that the eye, in order to view the falling water, continued to follow it downward for a time, then twitched up only again to follow it down, and so on. On now directing the gaze to the bank, the objects there apparently move in the opposite direction because the observer is unconsciously still continuing the same movements of the eyes as when gazing at the waterfall, and because this motion is unconscious the objects on the bank are consequently judged to move. The objection to this explanation of these illusions of motion is that they can be obtained in the after-image with the eyes closed, and, further, that two opposite motions can be simultaneously produced in the same retina. These facts, which with others were brought out by Bowditch and Hall, conclusively show that the explanation of Helmholtz will not apply in these cases. No other explanation of the phenomena is, however, at present formulated.

In considering the centre to which these lines of direction are referred, E. Hering drew attention to the fact that we perceive the direction of objects seen as if both eyes were fused into one, and that one was located in the median plane of the head. This cyclopean eye is considered as so constructed that the retinal images are projected outward in the line of vision of that eye.

The habit of thus attending only to the mean direction of the lines of sight is considered by Helmholtz to depend on the fact that the median vertical plane of the body is the one to which all objects are referred, so that an object neither right nor left lies in that plane, which also passes midway between the two eyes. Further, an object may lie to the right or left of this plane and bear the reverse relation to the vertical plane (parallel to the median vertical plane) of the homonymous eye. In practice, we thus fuse the directions of both the optic axes and refer the lines of sight to a point in the head midway between the two eyes. That this process results from habit is indicated by the fact that variations occur in the location of the cyclopean eye, and that fixation of the attention on the impressions from one eye alone serves to make that for the time being the reference point. Other observations indicate the same conclusion.

The above statements are mainly from Helmholtz's "Physiologische Optik," where they are elaborated.

Henry Herbert Donaldson.

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DISEASE, FATALITY OF.—(Ratio of Deaths to Cases.) The question is often asked, Out of a given number of cases, how many die? The answer to this question is derived from the observations of physicians in active practice, both in hospitals and in private practice. The fatality in hospitals, as a general rule, is usually greater than that of private practice, since the milder cases are not usually sent to hospital for treatment.

The enactment of laws requiring the notification of infectious diseases has enabled the health officers of cities to contribute a considerable amount of information upon this subject, so far as the fatality of the principal infectious diseases is concerned.

The following figures are the results of observations collected from six States (Connecticut, Massachusetts, Michigan, Indiana, Rhode Island, and Vermont), and from nineteen of the principal cities in the United States, during the five years, 1894–98.

In these States and cities there were reported to the sanitary authorities 619,765 cases of smallpox, typhoid fever, scarlet fever, diphtheria, and measles in the period mentioned, and there were in the same States and cities 75,715 registered deaths from the same causes during the same time.

These cases and deaths were distributed as follows:

Diseases.	Reported cases.	Registered deaths.	Fatality, per cent.
Smallpox	9,222	2,385	25.8
Typhoid fever	69,758	13,284	19.0
Diphtheria and croup	195,783	44,411	22.7
Scarlet fever	127,847	9,211	7.2
Measles	217,755	6,424	2.8

In the compilation of these figures it was found necessary to reject the returns of several entire States and cities, in consequence of manifest deficiency in the number of reported cases.

The use of antitoxin for the treatment of diphtheria became general in the early months of 1895 throughout the country. If, therefore, the returns for the year 1894 be treated separately it appears that there were 25,844 reported cases, and 7,654 deaths in that year, the fatality being 29.6 per cent., while the fatality of the remaining years was only 21.6 per cent.

Treating the year 1898 in the same manner, the fatality was only 20.5 per cent., or the ratio of 31,494 cases to 6,471 deaths. In two States and seven cities combined, having a total population of 4,250,000, the fatality from diphtheria in 1894 was 29.7, and in the same places in 1898 it was only 14.6, confirming the statement that the diphtheria fatality has been cut in twain since the general introduction of antitoxin treatment. It is also quite noteworthy that in several large cities, situated a thousand miles apart, the diphtheria fatality before 1895 was quite uniformly from 29 to 30 per cent.*

The following figures are the result of observation in England during the eight years, 1891–98, under the operation of the English Notification Act. The diseases quoted are smallpox, scarlet fever, diphtheria and croup (considered together), typhus fever, typhoid fever, and erysipelas. The number of reported cases of these was 974,907, and the deaths from the same causes were 89,864:

FATALITY OF CERTAIN DISEASES IN ENGLAND (1891–1898).*

Diseases.	Reported cases.	Registered deaths.	Fatality, per cent.
Smallpox	27,613	2,639	9.6
Scarlet fever	538,828	23,034	4.3
Diphtheria and croup	167,452	37,304	22.3
Typhus fever	2,441	522	21.4
Typhoid fever	126,967	22,208	17.5
Erysipelas	111,606	4,157	3.7

*Compiled from the reports of the Local Government Board of England for the years 1891–1898 inclusive.

The fatality in different years varied for the different diseases as follows (1891 being excepted, as notification was at that time comparatively incomplete): Smallpox, a maximum of 17.2 per cent. in 1896, and a minimum of 6.8 per cent. in 1895; scarlet fever, a maximum of 4.8 per cent. in 1894, and a minimum of 3.7 per cent. in 1898; diphtheria and croup, a maximum of 25.1 per cent. in 1894, and a minimum of 18.6 per cent. in 1898; typhus fever, a maximum of 26.9 per cent. in 1893, and a minimum of 19.5 per cent. in 1895; typhoid fever, a maximum of 17.8 per cent. in 1892, and a minimum of 16.8 per cent. in 1898; erysipelas, a maximum of 4.7 per cent. in 1892, and a minimum of 3.1 per cent. in 1898.

The fatality of smallpox showed a wide variation in different years, the variation being undoubtedly dependent upon the relative protection afforded by vaccination in the community attacked. In some parts of England vaccination has been neglected to a much greater degree than in others. (For the comparative fatality of smallpox in the vaccinated and unvaccinated, see *Vaccination* in a later volume.)

The fatality of diphtheria in recent years appears to have undergone decided modification under the use of antitoxin, as already shown.

If the figures for the four years, 1891–94, previous to the introduction of antitoxin in England, are compared with those of the four years, 1895–98, succeeding the introduction, a marked decrease is shown, the fatality of the previous period having been 24.3 per cent., while those of the latter period were 20.8 per cent. The fatality in the last year of record, 1899, had fallen to 17.3 per cent.

In Massachusetts where free distribution of antitoxin has been made throughout the entire State since March, 1895, the fatality for diphtheria had fallen from 28.3 per cent. in the four years (1891–94) to 14.9 per cent. in the succeeding six years (1895–1900) and to 10.2 per cent. for 1900.

Observations in the same State also show that the fatality among those who were treated with antitoxin was 11.2 per cent., or 657 deaths out of 5,888 cases. The number treated was much larger than this, but this number 5,888 represents those in relation to whom returns were made to the State Board of Health by attending physicians. This includes cases in private practice and in hospitals.*

The probability that any one will die when attacked with a given disease differs very much in degree with the character of the disease. For example, compare the fatality of chickenpox with that of smallpox, or that of hydrophobia or of tetanus with that of measles or mumps.

Fatality differs also with age and to some degree with sex. It also is modified by artificial conditions introduced for the purpose of limiting its severity, such as vaccination and the use of antitoxin.

The general degree of resistance to the fatal result from all causes is greatest at about eleven or twelve years of age.

Samuel W. Abbott.

DISINFECTANTS.—Littré, in his "Dictionary of the French Language," defines disinfectants as follows: "*Désinfectants*, substances qui détruisent chimiquement les mauvaises odeurs." This is the popular sense in which the word is used in this country and in Europe. Vallin, in his "Traité des Désinfectants et de la Désinfection," says that it is impossible to accept this definition, for the reason that it is not sufficiently comprehensive. He says: "We may say with reason that every bad odor renders disinfection necessary, but it does not follow that disinfection is useless when there is no emanation appreciable to the sense of smell" (*loc. cit.*, p. 3). After discussing the subject at some length, Vallin gives the following definition as that preferred by him: "Disinfectants are substances capable of neutralizing morbific principles, virus, germs, miasms, or of decomposing the fetid particles and gases which are disengaged by organic matter undergoing putrefaction" (*loc. cit.*, p. 6). On another page (2) Vallin admits that it is, perhaps, unscientific "to introduce into the idea of disinfection the suppression of odors which offend the sense of smell"; for, he says, "the bad odor is not injurious in itself; it is an epiphenomenon which does not necessarily give the measure of the injurious properties of the air, or of any substance whatever." Nevertheless the popular sense in which the word is used is included in his definition, because, as he says, "it is necessary to avoid doing violence to the ordinary sense of words" (p. 2).

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* "Public Hygiene and State Medicine in the United States," a monograph contributed to the Paris Exposition of 1900, p. 22.

* "Thirty-first Annual Report of State Board of Health of Massachusetts," 1899, p. 667.

When the ordinary sense in which a word is used leads to confusion, we think it better to insist upon its being used in a more limited and scientific sense, and to instruct the public as to the exact meaning which we would attach to it. We, therefore, prefer the definition which has been given by the Committee on Disinfectants of the American Public Health Association: "The Committee would define a disinfectant as an agent capable of destroying the infective power of infectious material." This does not commit us to any theory as to the exact nature of the agent which gives to infectious material its infecting power, but it draws a line between the morbific agents which produce that class of diseases known as infectious —which it is the object of disinfectants to destroy—and other substances which may injuriously affect man, such as the gases of putrefaction and other toxic agents. From our point of view we do not disinfect a privy vault by destroying the sulphureted hydrogen given off from its contents, any more than we would disinfect the atmosphere of a laboratory by neutralizing the fumes of chlorine or of sulphur dioxide given off during an experiment. To make our position entirely clear we cannot do better than to quote further from the "Preliminary Report of the Committee on Disinfectants":

"The object of *disinfection* is to prevent the extension of infectious diseases by destroying the specific infectious material which gives rise to them. This is accomplished by the use of *disinfectants.*

"There can be no partial disinfection of such material; either its infecting power is destroyed or it is not. In the latter case there is a failure to disinfect. Nor can there be any disinfection in the absence of infectious material.

"Popularly, the term disinfection is used in a much broader sense. Any chemical agent which destroys or masks bad odors, or which arrests putrefactive decomposition, is spoken of as a disinfectant. And in the absence of any infectious disease it is common to speak of disinfecting a foul cesspool, or bad-smelling stable, or privy vault.

"This popular use of the term has led to much misapprehension, and the agents which have been found to destroy bad odors—*deodorizers*—or to arrest putrefactive decomposition—*antiseptics*—have been confidently recommended and extensively used for the destruction of disease germs in the excreta of patients with cholera, typhoid fever, etc.

"The injurious consequences which are likely to result from such misapprehension and misuse of the word disinfectant will be appreciated when it is known that:

"Recent researches have demonstrated that many of the agents which have been found useful as deodorizers, or as antiseptics, are entirely without value for the destruction of disease germs."

If it were demonstrated that every kind of infectious material owes its specific infecting power to the presence of known micro-organisms, we might bring this article to a close by referring the reader to the title *Germicides*, under which a full account will be found of the present state of knowledge with reference to the germicide power of the chemical agents known as disinfectants, as determined by biological tests.

But this is not yet demonstrated, and our knowledge relating to the comparative value of disinfectants is to a considerable extent empirical, being based upon the practical experience of sanitarians. This experience, however, is not in conflict with the view that the infectious agent in those diseases which have not been proved to be germ diseases—smallpox, yellow fever, scarlet fever, etc.—is in truth a living organism. On the other hand, the disinfectants which, independently of theory, have gained the confidence of sanitarians, are for the most part potent germicides, *e.g.*, chlorine, sulphur dioxid, etc.; or they are at least antiseptics of greater or less value, *e.g.*, the metallic chlorids and sulphates.

The same is true as regards the disinfectants which have been tested experimentally upon various kinds of infectious material, such as vaccine virus, anthrax blood, septicæmic blood, etc., without reference to the nature of the infectious agent contained in the material disinfected, the test of disinfection being made by inoculation into susceptible animals. The writer, in 1881, made an extended series of experiments of this kind, in which the blood of a rabbit just dead from an infectious form of septicæmia was the material to be disinfected. The comparative value, as disinfectants, of the agents tested corresponded, in general, with the germicide power of the same agents as subsequently determined in another series of experiments (1883). In the last-mentioned experiments the destruction of the test organisms in culture solutions was demonstrated by the failure of these organisms to grow in a suitable medium after having been exposed for a given time to the action of the germicide agent in a certain proportion. As the infectious character of the septicæmic blood in the first series of experiments had been demonstrated to be due to the presence of a micrococcus, this correspondence in the results obtained by the two methods was, *a priori*, to have been expected.

In the experiments which have been made upon vaccine virus, results have also been obtained which, in the main, correspond with the germicide value of the agents tested, as established by the biological method. As we have no direct evidence that in this case disinfection consists in the destruction of germs, a brief account of these experiments, and of others made directly upon different kinds of virus, will be given in the present article. For the experimental data relating to the germicidal power of various chemical agents, the reader is referred to the article under the title *Germicides*.

HEAT.—As long ago as 1831, Dr. Henry, of Manchester, tested the action of dry heat upon vaccine virus, and found that the virus no longer produced any result upon inoculation when it had been exposed to a temperature of 60° C. (140° F.) for four hours. In similar experiments made by Baxter (1875), in which the time of exposure was reduced to twenty-five minutes, it was found that a temperature of 90° to 95° C. (194° to 203° F.) was required to insure complete destruction of infecting power of virus dried upon ivory points. The virulence of *fresh* vaccine virus is destroyed at a considerably lower temperature. In a report made to the Congress of Amsterdam in 1879, Carsten and Coert, as the result of a large number of experiments, arrived at the conclusion that "animal vaccine heated to 64.5° C. (148.1° F.) for thirty minutes loses its virulence."

SULPHUR DIOXID.—The power of sulphurous acid gas to destroy the virulence of vaccine virus has been demonstrated by several experimenters. Ten minutes' exposure in an atmosphere "saturated with sulphurous vapor" was found, both by Dougall and by Baxter, to neutralize the virulence of vaccine dried upon ivory points (Vallin). In these experiments the exact amount of sulphur dioxid in the air of the disinfection chamber is not stated. Experiments made by the writer in 1878 showed that *liquid* vaccine is rendered inactive by exposure for four hours to sulphur dioxid in the proportion of five volumes per one thousand of air. In experiments with dried virus upon ivory points, made in 1880, it was found that virulence was destroyed by six hours' exposure in an atmosphere containing one per cent. of this gas.

Baxter and Vallin have tested the disinfecting power of sulphur dioxid upon the virus of glanders. The first-named experimenter found that four parts to one thousand by weight, in solution, destroyed the virulence of material obtained from nodules (rubbed up in water) from the lung of an animal with glanders. Vallin experimented with virulent pus from an abscess, obtained from a patient with glanders in the hospital of Val de Grace. This pus was proved, by inoculations into guinea-pigs and other animals, to produce the characteristic lesions of glanders. Some of this pus placed in a watch glass was exposed for twelve hours to sulphur dioxid, generated by burning 2 gm. of sulphur in a box having a capacity of 100 litres (= 14 volumes of SO_2 to 1,000 volumes of air). Disinfection was complete, as proved by inoculation.

CHLORINE.—Experiments made by Dougall, and by Baxter, upon liquid vaccine show that to insure the disinfection of this material, chlorine must be absorbed in sufficient quantity to give the liquid virus an acid reaction. Baxter found that 0.14 of one per cent. was insufficient, while the presence of 0.163 per cent. of chlorine in the lymph neutralized its virulence. In experiments with dried vaccine upon ivory points, Baxter found that exposure for thirty minutes in an atmosphere "saturated with chlorine" was necessary in order to accomplish disinfection. In experiments made by the writer in 1880, it was found that the virulence of dried virus upon ivory points was destroyed by exposure for six hours in an atmosphere containing one volume per cent. of chlorine gas.

CARBOLIC ACID.—The power of carbolic acid to destroy the virulence of vaccine virus has been established by the experiments of Braidwood and Vacher, of Baxter, and of Hoppe-Seyler. But to accomplish this result, the pure acid must be mixed with the lymph in a proportion of two per cent., and a certain time must be allowed for its disinfecting action. Both Hoppe-Seyler and Baxter found that two per cent. destroys the virulence of liquid vaccine, while one per cent. fails to do so. On the other hand, in Braidwood and Vacher's experiments 2.5 per cent. failed when vaccination was practised *immediately* after mixing the disinfectant with the liquid virus.

Baxter has also experimented upon the virus of glanders, and found that two per cent. was successful in destroying its infecting power, while 0.5 per cent. failed to act as a disinfectant (Smart). In the writer's experiments (1881), with the blood of septicæmic rabbits, infective virulence was destroyed by 1.25 per cent., while 0.5 per cent. failed.

It is impossible in an article of this character to give a complete account of the experimental evidence on record relating to the comparative value of disinfectants. But a careful consideration of this evidence, as obtained in practice by sanitarians, and in laboratory experiments made directly upon infectious material (test by inoculation), or upon pure cultures of various micro-organisms (test by cultivation), shows that many agents commonly used are quite unreliable, as used, and that for practical purposes the agents which can be safely recommended as disinfectants are few in number.

The following list embraces those which we believe to be the most generally useful and available for disinfecting purposes: Dry and moist heat; formaldehyd, sulphur dioxid; the hypochlorites of lime and of soda (chlorid of lime, and Labarraque's solution); caustic lime, mercuric chlorid; cupric sulphate; carbolic acid.

We shall briefly indicate the special purposes for which one or the other of the agents named seems best adapted.

DISINFECTION OF EXCRETA, ETC.—Success in restricting the extension of infectious diseases will depend largely upon the proper use of disinfectants in the sick-room. For the disinfection of excreta the most available chemical agents are: 1. *Chlorid of lime.* Dissolve in water, in the proportion of four ounces to the gallon of water (Standard Solution No. 1 of the Committee on Disinfectants of the A. P. H. A.); use one quart of this solution for the disinfection of each liquid discharge in cholera or in typhoid fever. For solid fæcal matter a stronger solution or a larger quantity will be required, and it will be prudent to use a larger quantity of the standard solution recommended for a very copious liquid discharge. 2. *Carbolic acid,* a five-per-cent. solution to be used in quantity at least equal to the amount of material to be disinfected. 3. *Caustic lime,* in the form of freshly prepared milk of lime—this should contain about one part by weight of hydrate of lime mixed with eight parts of water. To be used in amount equal to that of the excreta to be disinfected. 4. *Cupric* sulphate, a four-per-cent. solution.

DISINFECTION OF THE PERSON.—The hands of those who wait upon persons sick with infectious diseases should be washed in an aqueous solution of mercuric chlorid of the strength of 1 to 1,000; or of carbolic acid, 1 to 50; or of chlorid of lime, 1 to 100; or of Labarraque's solution, 1 to 10. The same solutions may be used for washing soiled surfaces upon the body of the patient, and for instruments and utensils which have been exposed in the sick-room.

For a complete bath, carbolic acid, 1 to 100; mercuric chlorid, 1 to 5,000; or Labarraque's solution, 1 to 20, may be used. The dead should be wrapped in a sheet saturated with a solution of mercuric chlorid of 1 to 500; or of carbolic acid, 1 to 20; or of chlorid of lime, 1 to 25.

DISINFECTION OF CLOTHING.—"Boiling for half an hour will destroy the vitality of all known disease germs, and there is no better way of disinfecting clothing which can be washed than to put it through the ordinary operations of the laundry" (Prelim. Rep. of Com. on Disinfectants). Clothing may be disinfected by immersion for two hours in a solution of mercuric chlorid of the strength of 1 to 1,000; or of cupric sulphate, 1 to 100; or of carbolic acid, 1 to 50; or of chlorid of lime, 1 to 100 (the bleaching properties of chlorid of lime must be remembered). Clothing which would be injured by washing or immersion in a disinfecting solution may be disinfected by steam, by formaldehyd, by sulphur fumigation, or by dry heat, in a properly constructed "oven." In the absence of spores, a temperature of 230° F., maintained for three hours, will be sufficient. The clothing must be freely exposed, for the penetrating power of dry heat is very slight. The spores of bacilli require a temperature of 284° F., maintained for three hours, for their complete destruction. This temperature injures woollen fabrics (Koch).

Fumigation with sulphur dioxid has been largely relied upon for the disinfection of clothing. To be effectual, the articles to be disinfected must be freely exposed to its action, in a well-closed chamber, for a period of at least twelve hours. Burn three pounds of sulphur for each thousand cubic feet of air space in the room. Since it has been demonstrated that *formaldehyd* gas is much superior to sulphur dioxid as a germicide, this gas has to a considerable extent taken the place of SO_2 for the disinfection of clothing and other articles which would be injured by immersion in boiling water or in a disinfecting solution. But disinfection by *steam* is to be recommended whenever a suitable steam disinfecting apparatus is available. It must be remembered, however, that neither steam nor the gases above mentioned (formaldehyd, SO_2) can be relied upon to penetrate to the interior of mattresses, bundles of clothing, etc. To accomplish this it will be necessary to have a steam disinfecting chamber in which a vacuum can be produced prior to the admission of steam.

DISINFECTION OF THE SICK-ROOM.—"In the sick-room no disinfectant can take the place of free ventilation and cleanliness. It is an axiom in sanitary science that *it is* *impracticable to disinfect an occupied apartment*" (Prelim. Rep. of Com. on Disinfectants). The most reliable gaseous disinfectants are formaldehyd gas, sulphur dioxid, and chlorine.

"The object of disinfection in the sick-room is, mainly, the destruction of infectious material attached to surfaces or deposited as dust upon window ledges, in crevices, etc. If the room has been properly cleansed and ventilated while still occupied by the sick person, and especially if it was stripped of carpets and unnecessary furniture at the outset of his attack, the difficulties of disinfection will be greatly reduced" (Prelim. Rep. of Com. on Disinfectants). *Formaldehyd* must be given the first place among volatile or gaseous disinfectants because of its high germicidal value and its non-toxic properties; also because it does not injure gilt work or articles made of wool, silk, cotton, linen, or leather. Iron and steel are attacked by the gas, but copper, brass, nickel, and zinc are not, and polished steel resists its corrosive action. Formaldehyd gas is obtained for practical use (*a*) by the oxidation of methyl alcohol by means of a lamp specially constructed for this purpose; (*b*) by the volatilization of paraform; (*c*) by the volatilization of an aqueous solution of the gas. A forty-per-cent. solution put up by German manufacturers under the name of formalin has been largely used. (A sixty-per-cent. solution of formaldehyd gas in methyl alcohol is sold in Germany under the name of "Volzin.")

In practice the last-mentioned method (*c*) appears to be the most useful. A suitable apparatus for rapidly boiling the formalin will be required. Calcium chlorid is usually added to the solution of formaldehyd to prevent polymerization. The "formol gas generator" of the Kny-Scheerer Company, of New York, has been used with success in the United States army; also the smaller and less expensive "formaldehyd gas generator" of Lentz—manufactured by Charles Lentz & Sons of Philadelphia. Experiments made under the direction of the Chicago Board of Health show that apartments may be disinfected by hanging up in them sheets wet with formalin. All experimenters agree that the penetrating power of formaldehyd gas is slight, unless the vacuum process is employed, and that it can be relied upon only for the disinfection of surfaces and of clothing freely exposed to its action by being suspended in a disinfecting chamber or apartment requiring disinfection. According to Professor Robinson, surface disinfection of the sick-room and of articles suspended in it requires the use of two litres of wood alcohol, oxidized by the use of a suitable lamp, for a room having a capacity of three thousand cubic feet, or the volatilization of 250 c.c. of formalin for every one thousand cubic feet of air space. The rooms should be kept closed for twelve hours.

Fumigation of the sick-room and of infected clothing by sulphur dioxid is still practised to a considerable extent, and the value of this agent as a disinfectant has been demonstrated by numerous carefully conducted experiments. Dry sulphur dioxid has but little germicidal action when brought in contact with dried infectious material, and none at all upon the spores of bacteria. But when the material to be disinfected is moist, or the atmosphere of a room is charged with vapor, the disinfecting power of this gas is considerable, and it should not be rejected because it does not destroy the spores of the anthrax bacillus, which have been largely used as the test in experiments relating to the germicidal value of this and other chemical agents. We now know that the typhoid bacillus, the diphtheria bacillus, the bacillus of glanders, the cholera spirillum, and the various pathogenic micrococci do not form resistant spores, and we have satisfactory evidence that the specific infectious agent of smallpox may be destroyed by the proper use of sulphur dioxid. As in the case of formaldehyd gas, only superficial disinfection can be effected by the usual method of sulphur fumigation. This consists in carefully closing the room to be disinfected, after hanging up articles of clothing, curtains, etc., so that they may be freely exposed to the action of the gas. Three pounds of sulphur should be burned in the room for every one thousand cubic feet of air space, and at least twelve hours should be allowed for the action of the disinfectant before the room is opened. After the disinfection of an apartment and its contents by a gaseous disinfectant and free ventilation for the escape of the gas, it will be well to wash all exposed surfaces with a solution of mercuric chlorid of the strength of one part to one thousand, or with a two-per-cent. solution of carbolic acid, and to whitewash plastered walls.

Disinfection of Ships.—Sulphur dioxid has been largely used in the disinfection of ships and apparently with success, when properly done at a quarantine station by experienced officials. In the case of ships infected with yellow fever, it acts upon infected mosquitoes, which are promptly destroyed by this gas. The directions given with reference to the disinfection of apartments on shore are those that apply as well to the disinfection of the various compartments of a ship.

George M. Sternberg.

DISINFECTION.—The important part which disinfection plays in the prevention of infectious diseases demands for it the most careful consideration. Prior to 1880 but little was known of this subject which was of any definite scientific value. However, during the past twenty years exhaustive bacteriological research has demonstrated the great value of some of the agents known as disinfectants and the utter worthlessness of others. It may be said that we have entered upon a new era in sanitation and are now scientifically familiar with this subject. This advance is largely due to the stimulus given to bacteriological investigation by the work of Pasteur and Koch, who for the first time gave to us conclusive evidence of the germ origin of many of the infectious diseases. Before the period referred to, the character of the disinfection employed was influenced largely by theory. This can hardly be a subject for criticism, as at that time but few data existed upon which could be based a truthful estimate of the germicidal value of alleged disinfectants.

Much confusion exists as to the proper meaning of the term disinfectant. It is commonly confounded with antiseptics which do not necessarily destroy pathogenic organisms but simply inhibit or hold in check their activity or propagation, and with deodorants which neutralize or destroy offensive odors and may have no germicidal action. Strictly speaking, therefore, no agent is a disinfectant unless it destroys all germs with which it comes in contact. Custom, however, permits of considerable latitude in the use of this term, which is frequently improperly and loosely applied to many articles, both proprietary and otherwise, which are advertised and recommended for use in disease and to prevent infection, without the slightest evidence that they are germicides. That the value of disinfection in the prevention of infectious diseases, and the necessity for discrimination in the selection of agents for this purpose, are not more clearly and fully appreciated is largely due to the fact that sufficient instruction on this subject is not included in the curriculum of medical colleges. The recent action on the part of the faculties of these institutions in New York City in establishing a special course of instruction in practical sanitation deserves the highest commendation.

It is only necessary to observe carefully the various methods of disinfection now employed to appreciate that there is yet much to learn regarding this important branch of sanitary science. We still find the saucer of carbolic placed under the bed, the spraying of the sick-room with a proprietary solution, and occasionally the burning of a small piece of sulphur in the apartment still occupied by the patient. It seems hardly necessary to say that these measures, which bear the marks of antiquity, are absolutely worthless; unfortunately, however, they are still relied upon as effective germicidal agents. Bacteriological research has proven that enough sulphur dioxide to disinfect an apartment would arrest respiration in both man and animals, and although formaldehyde in sufficient quantity to disinfect does not always kill insects, vermin, and the lower order of animals, it would undoubtedly prove fatal to man. This will also apply to the use of sprays, etc. Therefore an apartment cannot be disinfected until the termination of the case. Disinfection is only too often performed in a perfunctory and careless way and left in the hands of those who are not familiar with modern scientific methods.

In order properly to perform disinfection we must be able to distinguish true disinfectants from agents which have no germicidal value. We must also know when disinfection is required, and the means of performing the same. This involves a careful study of the material liable to transmit disease. Without a clear perception of the law governing modern disinfection, and the agents by which this work is accomplished, we are in the position of using tools with which we are not familiar. The literature of disinfection at the present time embraces so much definite information that there can be no valid or reasonable excuse for the employment of inefficient or improper methods.

In the consideration of this subject we must first realize the value of nature's disinfectants—fresh air and sunlight. Not to understand or utilize their power means that our efforts to prevent or control infectious diseases will frequently meet with doubtful success. Of all that bacteriological research has taught us, nothing has been of more importance than the knowledge we now possess of the wonderful germicidal power of the agents to which I have just referred. The disappearance of infectious diseases in communities where there are no modern or organized means of combating this danger is largely due to sunlight and fresh air, which are always available and therefore can be brought in contact with specific germs. It has been proven that most of the pathogenic organisms are quickly destroyed when exposed to sunlight and air, whereas they frequently resist the action of chemical and other agents. This fact carries with it great significance, as it places in our hands at all times a germicidal power which, if properly used, contributes largely toward protecting a community against infectious disease, and is particularly valuable when other means of disinfection, such as steam, sulphur, etc., are not at hand. When we fully appreciate the great value of air, sunlight, and cleanliness we have taken the first step in modern sanitation.

In speaking of the different disinfectants, I shall refer only to those in general use and which are scientifically known to be true germicidal agents.

Steam.—Of the disinfectants which it is within our power to create steam is by far the most valuable, inasmuch as absolute dependence can be placed upon it if properly employed. Its action is quick and deep penetration is assured—the latter being a most important consideration. These invaluable qualifications are not possessed by other disinfectants. The experiments made with steam at the New York State Quarantine laboratory, in 1897, showed that a moist temperature of 230° F., if kept up for a period of fifteen minutes, killed the bacilli of anthrax, bubonic plague, diphtheria, etc.—both those near the surface and those which were lodged deep down in the centre of unopened bundles; *i.e.*, it killed them under conditions similar to those which would be encountered in any work of general disinfection. Moreover, it was found that a moist temperature of 135° to 150° F., with an exposure of fifteen minutes, generally killed all the organisms employed in the test except anthrax, when they were more directly exposed as in superficial disinfection, but not when deep penetration was required. In the experiments in which a temperature of 230° F. was employed, the self-registering thermometers placed with the infected discs in the centre of large bundles of clothing, bedding, and blankets showed but little or no diminution in the temperature at that point, whereas in tightly rolled and closed packages of newspapers, weighing three pounds or more, the inside temperature sometimes showed a reduction of thirty or forty degrees; repeated tests showed that this result was uniform and that material usually presented for disinfection, such as clothing, bedding, etc., is easily penetrated by steam. The importance of this is evident, as in public or general disinfection it is impracticable to open and spread out all material received for disinfection, which requires great expenditure of time. The results of the experiments above referred to are in accord with those of other investigators, and it may be accepted that a temperature of 230° F., with an exposure of fifteen minutes, is destructive to all pathogenic organisms even in the spore forms. Although the ordinary cotton and woollen materials generally used in the manufacture of clothing, bedding, carpets, etc., are not injured by steam, it destroys articles made of rubber, leather, fur, material stiffened with glue, etc., and is apt to injure silks and satins and other delicate fabrics. In the modern method of steam disinfection, ordinary mail composed of letters and papers can be subjected to steam without injury or defacement of writing. Fortunately, however, modern sanitation does not regard this material as a menace to the public health, and the disinfection of mail has been practically abandoned. The potency of steam as a disinfectant, its reliability for deep as well as for superficial disinfection, and its rapidity of action, make it imperative that every community should be prepared to employ this agent when necessary. There can be no reasonable excuse for not complying with this modern sanitary requirement, as a simple and effective apparatus can now be purchased of the makers at a very reasonable price. A steam chamber into which can be squeezed a mattress is sufficiently large for disinfection in a small town. The purchase of an apparatus of this character is really a matter of economy, inasmuch as many articles, such as presumably infected mattresses, etc., can be saved, when otherwise it would be deemed necessary to burn them. It would be of comparatively little interest to enter into a detailed account of the evolution of the steam disinfecting chamber, which has passed through many changes until it has now reached a stage where it seems to comply with modern scientific requirements.

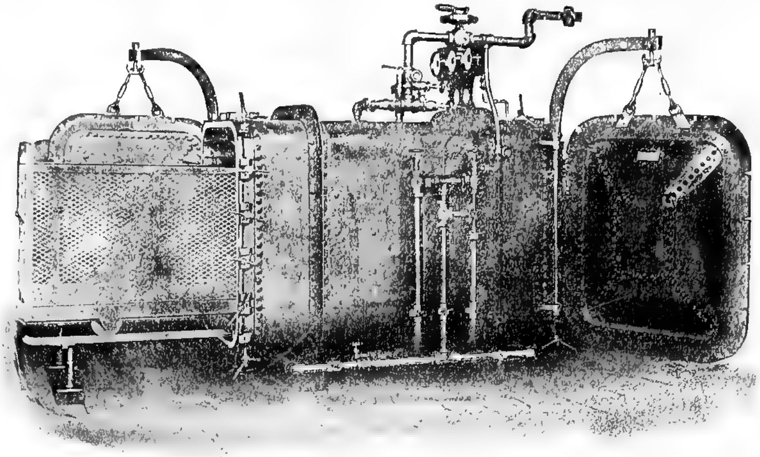

FIG. 1597 A.—Modern Steam Disinfecting Apparatus.

To describe this briefly I will cite from an article published in the *American Journal of the Medical Sciences*, of August, 1897, in which I have referred to the construction of such an apparatus.

"I can, perhaps, give no better idea of the modern perfected steam chamber than by describing the apparatus for disinfection by steam, now in use on the disinfecting steamer *James W. Wadsworth* at the New York quarantine station (Fig. 1597 A). This apparatus consists of a rectangular-shaped chamber having a double shell with a space of two inches between its walls. The inside dimensions of the chamber are thirty-nine by forty-eight inches by seven feet two inches long. The shells are made of $\frac{5}{16}$ inch open-hearth flange steel, riveted at the ends to heavy cast-iron rings, the outer surfaces of which are indented and contain 1.5-inch T-shaped rubber joints, for the purpose of making the doors air-tight. The latter are of a heavy convex type, are swung on cranes, and fastened to the chamber with turn-buckles. A car for the reception of material to be disinfected easily traverses the chamber. It is made of 1.5-inch angle iron and No. 6 galvanized iron netting. A movable track is so arranged that the car can be entirely withdrawn from either end of the chamber. The steam is supplied from the boiler of the steamer, where a pressure of sixty-five pounds to the square inch is maintained. Both moist and dry steam outlets have been constructed, which, by a system of valves, allow the operator to get almost any quality of steam desired. The steam enters through a 2.5-inch pipe to a reducing valve, which limits the pressure of the steam entering the chamber of the apparatus to the desired amount; at the present time it is set for fifteen pounds to the square inch. The pressure used in the chamber is in accordance with the temperature required. If a temperature of 230° to 250° F. is desired, steam at about ten pounds pressure is employed.

"For obtaining a vacuum in the chamber a steam exhauster is used. By means of valves this is readily changed to draw either from the space between the shells forming the walls or from the interior of the chamber. It acts on the principle of a siphon; a current of steam rushing by the mouth of a pipe opening from the chamber exhausts the air therein contained.

"A vacuum of twenty inches, which answers the purpose, can be obtained with the steam exhauster in one minute, while in the old method, by the use of an air pump, about ten or fifteen minutes were necessary to secure this result; besides, the air removed from the chamber is carried out with the steam in the exhaust, so that if micro-organisms are withdrawn in this way from the materials in the chamber they are acted upon by the steam in transit. This does not occur where an air pump is used.

"The advantages of the double jacket or shell over coils of steam pipes are numerous. There is a more equal diffusion of heat in the walls of the apparatus, inasmuch as the steam enters between the shells at all points, and not at the lower part of the apparatus, as in the case in which the steam is introduced by pipes laid in the floor of the chamber. The shell is thus evenly heated and materially aids the steam which is introduced in the chamber for disinfection. Leaks are frequently found where the pipe system is employed; these do not occur when the double shell is used; there is no formation of air-bound spaces in the double shell, which frequently interfere with securing the temperatures needed; and, finally, in the matter of cleanliness, the double jacket is very superior to the coils of pipes.

"The fresh-air inlet—which, as far as I am able to learn, was first used at this station, and which has proved of great practical value—consists of a 1.5-inch pipe connecting the interior of the chamber with the external air. It is fitted to the top of the apparatus. The external opening of the inlet is covered with a strainer of fine brass netting to prevent the entrance of foreign matter. The inlet is supplied with a valve to open and close it. The entire chamber is encased in a 1.5-inch layer of asbestos magnesia, which retains the heat in the chamber and prevents outside radiation. This it does in a very effective manner, the temperature of that portion of the boat in which the apparatus is placed being very little raised above that of adjoining apartments. The ends of the chamber open into rooms having absolutely no communication with each other, the infected end receiving the clothing removed from the disrobing room adjoining. The disinfected end opens into an apartment from which the clothing is given directly to the owners, who have passed through the bathrooms.

"The operation of disinfecting clothing, bedding, etc., with the steam chamber is as follows: The materials to be treated are placed in the cradle or car in the infected end (both ends of the chamber are never open at the same time), the door is then bolted, and a vacuum of about twenty inches is obtained by the steam exhauster. This is secured in about one minute. The object is not only to remove the air from the chamber, but also the air and moisture from the material to be treated, which, forming a cushion, prevents the proper entrance of the steam. Steam is now allowed to enter the chamber, which it does rapidly, producing a temperature of 230° to 240° F. within three or four minutes. My experience has been that 230° is the temperature that is needed for disinfection. This is unquestionably safe and can be depended upon to kill all known micro-organisms which may be in clothing and other articles presented for treatment, provided there is an exposure of fifteen minutes to this degree of heat. At the expiration of this time, *i.e.*, after an exposure of fifteen minutes to a temperature of 230°, the steam exhauster is again used, securing the same degree of vacuum (twenty inches). This now removes the steam from the chamber and from the texture of the clothing, etc., undergoing disinfection, the latter being a most important consideration, as will be shortly shown. As soon as a vacuum of twenty inches has been obtained the fresh-air inlet is opened and a current of fresh air is drawn through the chamber and its contents by the steam exhauster. After an exposure of eight or ten minutes to this treatment the door of the disinfected end is opened and the clothing, etc., after being unrolled and exposed for three or four minutes, becomes dry and can be at once worn.

"The degree of improvement in the drying process, which is the result of the combined action of the steam exhauster and the fresh-air inlet, can be appreciated only by one who has waited two or three hours or more for this same result. When it involves the detention of a ship at a quarantine station, its value is at once apparent. The importance of the rapidity with which this work is now performed and the materials dried is especially appreciated in the treatment of mail. Letters and papers treated with steam by the slower or older process were frequently injured by the disfigurement of the address and the unsealing of the letters. During the past three months the British India mail has been disinfected weekly at this station. The few letters which are sealed with wax, and packages containing books or other materials injured by heat, are set apart for disinfection by other methods and the remainder subjected to the process indicated above. So far, I have yet to see a letter the superscription of which has been affected, and very rarely have I found a letter unsealed or partly unsealed. This satisfactory result, I am certain, is due to the rapidity of action of the heat, and the use of the exhauster and fresh air inlet afterward, which rapidly dries and prevents the spreading of the ink and the unsealing of the package.

"The still more important and valuable effect of the vacuum is shown in the rapid and pronounced penetration which it insures. It gives a higher degree of temperature inside the packages, with a comparatively short exposure.

"The first series of tests presented for consideration show the influence of the vacuum in steam disinfection. In all the experiments which I have made I constantly used packages of newspapers, inasmuch as this material probably offers as much (if not more) opposition to penetration as any with which we have to deal. In the tests made without vacuum, although the steam exhauster is not used, the outlet which leads from the bottom of the apparatus and which allows the escape of water, the result of condensation, is opened for a moment after the chamber is closed, to allow a certain amount of the air contained in the chamber to be forced out by the incoming steam. This vent is imperative in carrying out the disinfection, as in an absolutely tight chamber the presence of all the confined air offers so much resistance that it is practically impossible to raise the temperature to the proper degree for disinfection. When the chamber is perfectly closed, it frequently requires half an hour or more to get a temperature of 210° F., whereas when the steam exhauster is used 240° F. can be reached in three or four minutes, and when the air in the chamber is simply released by opening the conductor on the floor of the chamber above referred to, the same temperature (240° F.) is attained in about eight or ten minutes. This, however, does not answer the same purpose as the vacuum which forcibly draws out the air contained in the chamber and its contents. . . ."

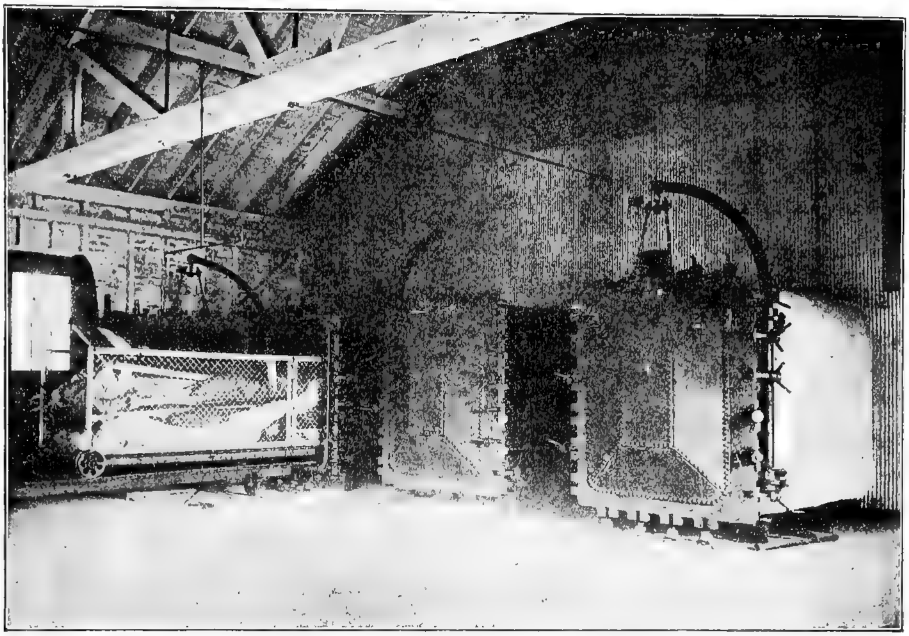

FIG. 1597 B.—Disinfecting Plant at Hoffman Island, New York Quarantine Station.

Since the above was written, there has been but little change in the character of this class of apparatus. Improvement in the method of closing or attaching the door and changes in some minor details have been made. Otherwise, the general principle of construction remains the same.

Fig. 1597 B shows one end of the New York Quarantine disinfecting station at Hoffman Island, presenting three very large steel chambers twenty feet in length, of the same construction as the one already described. One of them at the extreme left has recently been reconstructed for disinfection with formaldehyde gas. These chambers are sometimes used to their full capacity, as it is frequently necessary to disinfect as rapidly as possible the effects of five hundred or more steerage passengers. The cut shows only a part of the apparatus, the remainder being in the discharging room on the opposite side of the partition.

SULPHUR DIOXIDE AND FORMALDEHYDE GASES.—Although both of these are known to be disinfectants of great value and power, they are inferior to steam, principally because they cannot be depended upon to penetrate, and therefore can safely be used only for superficial disinfection; furthermore, their action is comparatively slow and their full power cannot be secured unless they are used in an air-tight apartment. It is impossible to secure this in house or ordinary disinfection, where more or less gas will escape even when great care is used to close all openings. In some of the less important details both formaldehyde and sulphur dioxide have special advantages. For instance, their employment does not involve an expensive or complicated apparatus, and so far as sulphur dioxide is concerned, a means by which the gas can be generated is available wherever a washtub or large bucket and pan can be found.

Sulphur Dioxide Gas is the oldest known disinfectant and has long been regarded as a very valuable germicidal agent. However, until recent years it has received but comparatively little investigation. In this country experiments were made by Drs. Dunham and Beebe at the Carnegie Laboratory, New York City, in 1892. Recently an investigation regarding the germicidal value of sulphur dioxide was made by Dr. H. D. Geddings, of the Marine Hospital Service, Washington, and during the past two years similar work has been carried on in the New York State Quarantine Laboratory, and is yet in progress. It may be said in a general way that the results which have thus far been obtained are practically the same, and show that sulphur dioxide is a valuable germicidal agent in the presence of moisture and when used for superficial disinfection, but that it cannot be depended upon to penetrate. In the experiments made in the Quarantine Laboratory it has been conclusively shown that when great humidity exists, or where steam has been introduced into the apartment, the germicidal action of this gas is notably increased. Sulphur dioxide is more or less erratic in its action. This undoubtedly is largely due to the difference in the amount of moisture present, although it would appear that there are other factors which influence its effect on pathogenic organisms with which we are not yet fully familiar. How far the moisture needed to insure the full germicidal effect of the sulphur dioxide used is supplied by the air is not yet fully settled. However, as the result of bacteriological research we are justified in assuming that on days when much moisture is present its action is decidedly more effective than at other times. It is when the air is very dry that the generation of steam in the apartment adds much to the thoroughness of the disinfection. On shipboard this is easily accomplished by carrying the steam through pipes or hose from the boiler to the apartment to be treated, where it should be introduced before the sulphur is ignited and distributed as evenly as possible; it is only necessary that the apartment should be rendered moist. In a dwelling-house this method cannot very well be carried out. However, some simple way can almost always be improvised by which moisture can be generated in the room. A simple and effective portable steam apparatus for this purpose is now in use at the New

York Quarantine Station consisting of a Swedish lamp set in a metal frame, over which is an attached receptacle for water. Above this is a handle by which the apparatus can easily be carried. The receptacle containing the water is supplied with four or five openings or spouts allowing the free escape of steam, which is rapidly generated by the intense heat produced by this peculiar lamp. It cannot be too firmly impressed that sulphur dioxide must not be relied upon to penetrate to any depth, and that it is effective as a disinfectant only when there is free and open exposure of the material to be treated. I am aware that there are those who believe that deep penetration can be secured by sulphur dioxide, but I am satisfied that this cannot be attained.

In comparing sulphur dioxide with other disinfectants, we find that it is very cheap and can almost always be secured even in small towns; this makes it available for immediate use; and then, besides, temporary means for the generation of the gas can quickly be prepared. I have used for some time a metal apparatus specially devised for sulphur disinfection; it consists of a heavy copper pan placed in an iron frame having a stationary receptacle for water underneath to protect the floor of the apartment. The apparatus is supplied with a handle and is comparatively light and easily carried (Fig. 1597 C). This principle is carried out by the use of an ordinary washtub or large bucket containing two or three bricks upon which is placed a galvanized iron pan or any metallic receptacle to hold the sulphur. The tub or bucket should contain water to a height sufficient to cover the bricks and the bottom of the sulphur receptacle. If the tub or bucket is not available, a metallic pail containing the sulphur can be placed in another partly filled with water, the latter in both instances not only protects the floor but the bottom of the metallic receptacle holding the sulphur, which is commonly a milk pan or something of this character. In the special sulphur apparatus to which I have just referred, the water is not directly applied to the sulphur pan as the copper is very thick and resists the action of the heat for a long time.

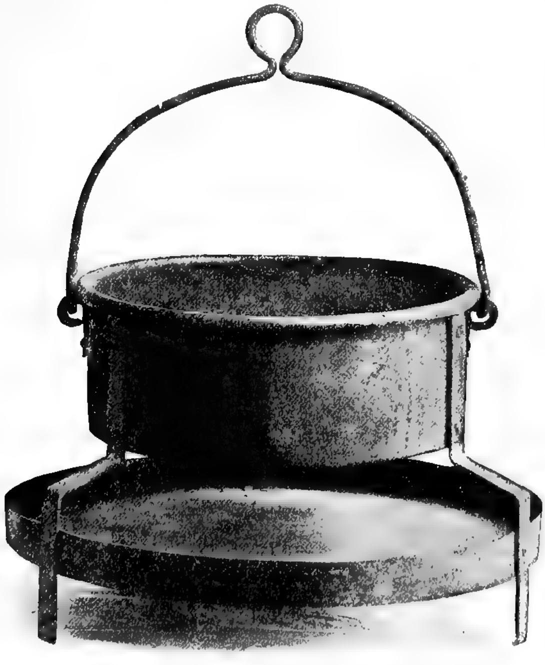

FIG. 1597 C.—Apparatus for the Generation of Sulphur Dioxide.

While sulphur dioxide has its advantages, its employment is sometimes attended with unpleasant results; for instance, it bleaches and in other ways injures certain material, such as tinted and gilded papers, silks, satins, etc., and when used in a room covered with richly tinted or gilded paper, it is quite sure to change the color or blacken the gilt.

Formaldehyde Gas.—Probably no disinfectant has ever received more careful and thorough investigation than formaldehyde gas. This has been to a great extent due to the fact that it was brought to the notice of the profession during a period of great activity in bacteriological research. Formaldehyde was probably first discovered in 1868 by Hoffman, a German chemist, who accidently found that a gas was produced by heating a platinum spiral over a common laboratory lamp burning wood or methyl alcohol. This observation excited but little attention at the time, and practically nothing was done toward determining its germicidal qualities. Twenty years afterward it was again brought to the notice of the profession by A. Trillat, a French investigator. Since that time, particularly during the past six or seven years, its germicidal qualities have been exhaustively treated. In reporting a series of experiments in the *New York Medical Journal* of October, 1897, I gave the following conclusion regarding formaldehyde.

"A careful analysis of the results obtained in the experimental investigation to determine the value of formaldehyde as a disinfectant will show that this agent cannot be depended upon for disinfection where deep penetration is required. . . . In packages made of blankets, clothing, etc., the action of formaldehyde upon infected discs placed inside is uncertain and not always the same. As a rule penetration does not occur; at least, organisms are not generally killed. This uncertainty would seem to decide the inefficiency of formaldehyde for deep penetration. For superficial disinfection, *i.e.*, of hangings, furniture, clothing, furs, silks, and other articles, which can be spread out and the surfaces exposed, formaldehyde is an agent of undoubted value, particularly as it does not as a rule injure the finest fabrics, and therefore may be safely used in an apartment furnished with delicate paper, hangings, and furniture.

"In the selection of the method for disinfection with formaldehyde, it is evident that the use of a formaldehyde solution simply exposed on pans is not to be considered provided other methods are available. The heating of pastils of paraformaldehyde is a simple, effective, and neat method of generating the gas, although at present it is a comparatively expensive one. It is necessary, however, that the apparatus for heating the pastils should remain in the apartment until the time for disinfection has expired. The gas is evolved slowly, and its release depends upon the proper performance of a lamp, which cannot be kept under observation, and which may not burn sufficiently long to reduce the pastils to ashes, or an accident may happen. I only refer to these as possibilities.

"The lamp for the generation of formaldehyde by the oxidation of methyl alcohol, which has already been described, is also an effective method as the experiments above shown will prove. This method of securing the gas is considerably cheaper than the preceding one, a pint and a half of wood or methyl alcohol, valued at twenty cents, being sufficient for the disinfection of a room having a space of one thousand cubic feet, whereas the expense of the pastils for this purpose is about seventy-five cents. Like the apparatus just described, the lamp can be purchased for a comparatively small sum, is easily manipulated, and is very satisfactory for house disinfection. However, it is practically subject to the same criticism, *i.e.*, that the process is comparatively slow and the lamp remains in the apartment and not under observation until the disinfection is completed. In a structure subject to change in position, as a ship, it is not improbable that an accident may occur.

"In the use of the autoclave and the new apparatus above referred to (the so-called regenerator) we have a method by which the formaldehyde is rapidly released and conveyed to the apartment to be treated, and when this is finished the instrument, which is operated from the outside, can be removed. In this way the material to be treated is subjected to almost the entire volume of gas before any considerable leakage from the room may occur, whereas in the slower methods, if the room is not made tight, at no time is the material in the room acted on by all or nearly all the gas generated. Short exposures are therefore only justified in cases in which the gas is rapidly released in the apartment by the autoclave or a similar apparatus. Further, this method does not require that the apparatus be left in this apartment. Thus is avoided the possibility of faulty action of the instrument or a change in its position. For general use, therefore, particularly for ship disinfection, I am in favor of this method of disinfection."

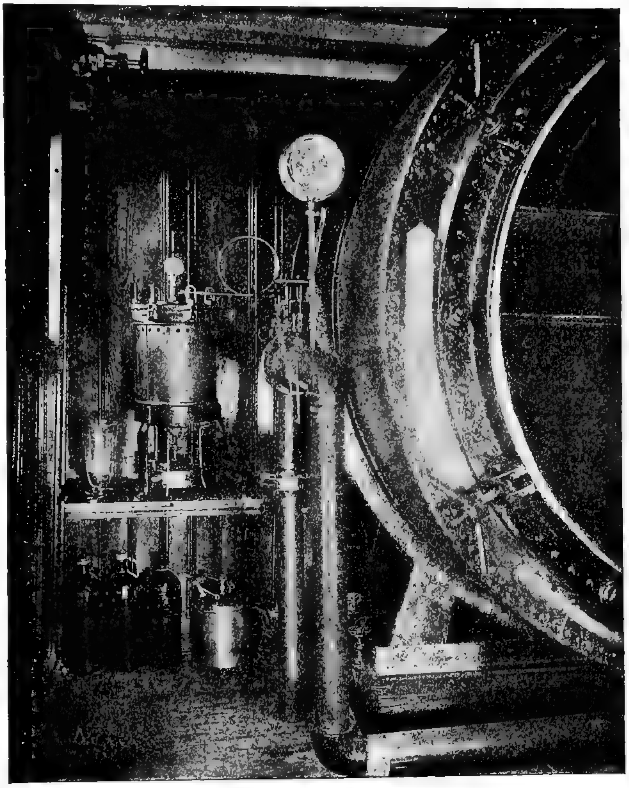

FIG. 1597 D.—Showing Air-tight Chamber, with Formaldehyde Apparatus Attached.

A continued experience with formaldehyde since the above was written has revealed no reason why I should change my opinion regarding the manner in which formaldehyde should be used, and that is by means of an apparatus which can be operated outside of the apartment, and which transmits the gas through a keyhole or other opening: in this way it is rapidly introduced; the process requires only a short time and is constantly under observation, and unsatisfactory results or danger which may follow the use of an apparatus acting slowly within the room and out of sight, are avoided; however, I do not mean to infer that the best results may not be obtained by many other forms of apparatus now in use. During the past three years numerous efforts have been made to show that formaldehyde gas can be relied upon for deep penetration. From the experimental work which has come under my personal observation I am satisfied that this agent can be depended upon only for superficial disinfection, *i.e.*, where the material to be treated is fully exposed. The fact that bacteriological experiments have shown that deep penetration is occasionally secured does not by any means justify the indiscriminate use of this agent for all forms of disinfection, and it must not be forgotten that instrument makers are not bacteriological experts and are generally enthusiastic regarding the merits of their apparatus. There are so many different ways of using formaldehyde, each having its own special merit, that it would be impossible to give a detailed account of them in this article; however, I have referred to the advantage of an apparatus which is operated outside of the apartment and under full observation. Description of these apparatus, as well as all others, their method of use, etc., can be procured from the makers through dealers in medical and surgical supplies.

In addition to steam, sulphur dioxide, and formaldehyde there are two other disinfectants which as germicidal agents deserve the most careful consideration. These are bichloride of mercury and carbolic acid, both of which are well known and in common use. It is well to bear in mind that many fatal results have followed the careless use of these agents, particularly the former. A solution of bichloride of mercury is colorless and odorless and may be mistaken for many other things. For general disinfection, therefore, a twenty-five per-cent. solution of this agent, colored with a small amount of fuchsin for identification, should be kept in stock, with a conspicuous label and instructions as to the amount to be used in making solutions of different strength. As the odor of carbolic acid is so distinctly characteristic, mistakes are not so liable to occur as with bichloride of mercury. Carbolic acid is only sparingly soluble and not more than a five-per-cent. solution can be made. Therefore it is just as well to make fresh solutions as it is needed for disinfection.

As a résumé, I may say that steam, sulphur dioxide, formaldehyde, bichloride of mercury, and carbolic acid are true disinfectants upon which full reliance can be placed. In this group will be found agents suitable for any form of disinfection. It is proper to add that boiling water is sometimes used for the disinfection of linen, bedding, etc., when no better means of treatment is available. It must be borne in mind, however, that the material to be treated must be subjected to boiling (not warm) water for at least one hour, in order to insure germicidal action.

Chloride of lime and quicklime are commonly used for the disinfection of privy vaults, cesspools, etc., and are valuable for this purpose. Salts of zinc and copper are now but little employed, and their value as disinfectants is somewhat questionable, while their power as dedorants is much inferior to that of bromine.

No agent is more uniformly destructive to germ life than bichloride of mercury, and it is very generally used for disinfection; it also constitutes the basis of many proprietary preparations; however, the statement that a certain solution contains corrosive sublimate justifies no public official in using it as a disinfecting agent, principally for the reason that he does not know from his own knowledge the amount of this agent in the mixture. Furthermore, no proprietary article recommended as a disinfectant can be sold as cheaply as a solution of bichloride of mercury can be prepared. The use of a proprietary mixture by a public health official means that he practically ignores the principles upon which modern disinfection is founded.

I have referred separately to the above agents, as we must be familiar with them in order scientifically and intelligently to treat material presented for disinfection.

The means by which infection is transmitted should next be considered. Sanitarians now more fully and clearly recognize that infectious diseases are frequently propagated by unrecognized, mild, ambulant, or convalescent cases, and that these are responsible for many outbreaks which are usually attributed to infected clothing, etc. Upon the appearance of smallpox or other infectious disease, it is the first duty of a public health official to ascertain if other cases of the same character exist in the community, particularly those of a mild type. Success in this direction will be secured only by a most careful and thorough inspection. By this means centres of infection are identified, and disinfection is performed not only where it is urgently needed, but where it will be followed by the most satisfactory results. Than what I have just stated, nothing more clearly shows the transition from old to new methods in public sanitation. While it is accepted by all that the clothing and effects of the sick constitute a medium of infection, considerable doubt now exists as to the danger from clothing actually worn by well persons, who have been in contact with cases of infectious disease which, until recently, has been generally regarded as a frequent source of infection. Within the past few years, careful investigation and practical experience have demonstrated that this is a medium of infection only in comparatively rare instances. It may occur when there is close and prolonged contact, particularly in the case of such diseases as smallpox and scarlet fever, and where the person exposed goes immediately to another apartment. While this should receive proper consideration and reasonable efforts should be made to prevent the transmission of disease in this way, it should be borne in mind that it is not a common medium of infection. The value of this knowledge which has come to us slowly cannot be overestimated, as it teaches us that an outbreak of an infectious disease calls for a most rigid inspection to discover the presence of mild and hitherto unrecognized cases. These constitute a greater menace to the public health than well-marked ones, which are more easily identified and cared for. In other words, we must understand that infectious diseases are usually transmitted by persons rather than by clothing and other material, and this knowledge justifies us in removing many restrictions which in the past have done much to hamper both the public and commerce.

Unreasonable and unscientific theories regarding the transmission of infection are unquestionably encouraged by worthless disinfection, which is more apt to be found in small communities where modern sanitary regulations are not enforced. It is in such places that little effort is made to ascertain the location of mild or ambulant cases.

If we are familiar with the principles which govern modern disinfection, but few specific rules are necessary in the performance of the important work.

The promptness with which a house or apartment can be disinfected depends largely upon the manner in which it is furnished. Hangings, and numerous articles of upholstered furniture, offer a very decided complication Therefore, if an opportunity is given to prepare a room for the reception of a person suffering from infectious disease, every effort should be made to remove all unnecessary furniture, hangings, carpets, etc. In this way the amount of material to be afterward disinfected is reduced to the minimum.

During the progress of the disease no opportunity should be lost to ventilate thoroughly the sick-apartment, as in no other way can the effect of a general disinfection be secured prior to the termination of the case. Not only is fresh air destructive to pathogenic organisms, but it is of inestimable value to the patient. Neither steam, nor formaldehyde, nor sulphur dioxide can be effectively employed while the patient is confined to the room, as their use in sufficient quantity to act as disinfectants would be destructive to human life. This knowledge should do away with old and farcical methods of spraying the room with so-called disinfecting solutions, placing saucers of carbolic acid under the bed and other methods of a like character, which are worse than useless, inasmuch as they inspire a sense of security which is not real. Therefore, during the existence of the disease, the use of germicides should be confined to the disinfection of discharges, bed-linen, dressings, etc.

At the termination of a case of infectious disease the patient should be thoroughly washed with soap and warm water, the scalp and hair included. After this the body may be sponged with a 1 to 3,000 solution of bichloride of mercury, particularly if desquamation has occurred. It is a practice also to place the patient at this time in a 1 to 5,000 bichloride of mercury bath. However, I am disposed to believe that the use of the sponge is equally satisfactory and safe. There is not a unanimity of opinion regarding the danger from the skin at this period, but it is safe to assume that when the acute symptoms have entirely subsided and convalescence is well along, and when desquamation is fully completed, there is but little if any danger, and the use of soap and water and bichloride may be relied upon to render the patient in no way a menace to the public health.

During the course of the illness bed-linen, dressings, etc., should be placed in a 1 to 2,000 solution of bichloride of mercury, or a five-per-cent. solution of carbolic acid for at least two hours, whenever soiled or when a fresh change is made, and under no circumstances should this material, which is frequently soaked with discharges or in other ways infected, be allowed to accumulate for the final disinfection. There is no doubt that attention to this important detail very materially diminishes the danger of infection in the sick-chamber.

In preparing a room for disinfection attention should first be given to the bedding, mattress, clothing, and other effects of the patient. These should be covered and tied up in clean sheets. If, unfortunately, a carpet has been left on the floor, it should be rolled up; by this means it will present a previously unexposed surface which is the equivalent of a fresh covering. These articles should be at once removed to a steam disinfecting plant.

The woodwork, bedsteads, etc., contained in the apartment should be washed with a 1 to 1,000 solution of bichloride of mercury. Afterward all windows and doors, —excepting one of the latter to be used for entrance and exit during the preparation for disinfection (which is subsequently sealed in the same way)—should be tightly closed and the cracks sealed by pasting over thin narrow strips of paper by means of ordinary flour paste, which can afterward be easily removed with water. The room should now be subjected to the fumes of sulphur dioxide, or formaldehyde gas, and not opened for at least twelve hours. Before closing the room it is well to know the situation of a window which can be easily opened to admit fresh air, as upon entering the apartment for the first time after disinfection there may be sufficient gas present to prove irritating to the respiratory tract. A wet sponge or towel applied to the face on entering the room will greatly diminish this annoyance. It is believed by some that a second fumigation should be performed, but if all linen, bedding, and discharges have been promptly disinfected during the progress of the disease and the room has been well aired, one fumigation properly performed will be sufficient, although the safety of this work depends largely on strict attention to details, such as spreading out of the material to be disinfected, sealing the room, and the proper use of disinfectants. In small towns where steam disinfection is not available, mattresses, comfortables, etc., should be burned, if there is evidence that they have been wet with discharges or otherwise soiled. There is no doubt that the danger from mattresses used by persons suffering from infectious diseases is very much over-estimated, particularly where they are covered with a rubber cloth or other good dressings, and in the majority of cases the use of sulphur or formaldehyde will destroy whatever infection may be present. However, such care is not always taken, and mattresses are frequently soiled. For this reason an unwritten law exists calling for their destruction by fire, provided they cannot be treated with steam.

The good results derived from a strict attention to details in the use of sulphur dioxide, as well as formaldehyde gas, has been strikingly shown in laboratory experiments. While the use of steam is almost always under the observation of those skilled in this work, disinfection by sulphur or by formaldehyde is commonly performed in houses or apartments by members of the family, and not under the observation of the attending physician. In these cases a sulphur candle, or a few small pieces of sulphur are burned without the slightest knowledge of the amount of cubic air space present. The sulphur is ignited by the use of a live coal, and little or no attention is paid to the sealing of windows and doors. Disinfection should always be under the direction of the attending physician or a sanitary officer. If the use of sulphur has been decided upon, after ascertaining the cubic air space of the apartment, four pounds of sulphur should be supplied for each one thousand cubic feet of space. This should be broken in small pieces and spread out in the receptacle. If the room is unusually large, it is better to have a number of receptacles, as in this way the pieces of sulphur are not too closely packed together, and the gas is more freely generated and more equally diffused. The use of the live coal as the means of igniting the sulphur should be discouraged, as when depended upon the combustion is very frequently imperfect. The sulphur should be liberally covered with alcohol and ignited by dropping a lighted match into the receptacle, the operator being as far away as possible. In this way the sulphur is almost always all consumed.

I have already referred to the importance of disinfecting sheets, linen, dressings, etc., as soon as they are soiled or removed from the bed. Discharges which constitute a most potent cause of infection should be received in receptacles containing a disinfecting solution, bichloride of mercury 1:1000, or a five-per-cent. solution of carbolic. Many physicians, nurses, and others in attendance on the sick are prevailed upon, principally on account of pleasant odors and strong recommendations, to use proprietary solutions for this purpose. I cannot too strongly condemn this practice, and desire to emphasize what I have already said in regard to this part of the subject, that disinfecting solutions should be freshly prepared and their composition and strength known to those in charge of the patient. It should be remembered that typhoid fever, diphtheria, etc., are often transmitted by the hands of the attendants. Therefore great care should be taken to prevent infection by this means.

While the value of carbolic acid as a disinfecting agent is indisputable, I believe it to be inferior to corrosive sublimate for the purpose to which I have just referred.

It is a common belief that theatres, churches, schoolrooms, etc., are frequently infected and require disinfection. This is erroneous. The presence for a short time of a person affected with smallpox or other infectious disease in a church or theatre, does not infect the building and does not call for a disinfection beyond the treatment of the seat occupied by him and of the objects in its immediate vicinity. Disinfection of a large structure, such as a public hall, is a most formidable proceeding, and if properly carried out, requires an almost endless amount of work, and is justified only under the most extreme conditions and the most prolonged exposure. The proper and continuous ventilation of these buildings combined with cleanliness offers the best protection against infectious disease. In schoolrooms the danger is not so much from the apartment itself as from contact with unrecognized cases. In these places children are frequently found who are apparently well, but in reality are suffering from diphtheria, scarlet fever, etc., in a mild form. This is so commonly a factor in the transmission of disease among school children that the New York City Department of Health some time ago appointed a number of medical inspectors, known as the "School Corps," who visit the public schools daily for the specific purpose of detecting mild or ambulant cases of infectious disease. The reports presented by these officers fully confirm the statement I have made regarding the danger from the latter class of cases. There are times when the disinfection of a schoolroom may be called for. In these instances the woodwork should be scrubbed with soap and water, or washed with a 1 to 1,000 solution of bichloride, and afterward subjected to sulphur dioxide or formaldehyde disinfection, followed by thorough ventilation. It is my belief that a careful scrubbing of the woodwork, desks, chairs, etc., with soap and water prior to the fumigation, will answer all requirements. We know that soap has strong antiseptic properties, and I am quite sure that the future will show that free scrubbing with this agent combined with thorough fumigation can be depended upon for disinfection not only in schoolrooms but elsewhere.

In ship disinfection the general principles to which I have already referred can be successfully applied. Experience has shown that infectious diseases, when present on shipboard, are found in the forecastle and steerage quarters, and rarely in the cabin or salon. Furthermore, modern investigation and practical experience have shown that we have little to fear from a ship's cargo, and unless there is reliable evidence that danger exists in this direction, we are not justified in attempting to disinfect the merchandise found in the hold of a ship. The disinfection of a vessel's cargo is the most formidable and difficult task that a quarantine officer is called upon to perform, and if properly done means the removal of almost every article of the cargo. Furthermore, it must not be forgotten that commerce is entitled to consideration, and that sensible quarantine regulations cannot insure complete protection against infectious diseases.

It is in marine sanitation that the danger from unrecognized mild, ambulant, and convalescent cases of infectious disease is fully appreciated. Sailors as a rule receive but little consideration, so far as their health is concerned, and are not released from work on account of trivial complaints, and it frequently occurs that they are affected with a mild type, or pass through the initial stage, of an infectious disease without any external evidence of it or reference to it on their part. Therefore it is imperative that this class of people shall be subjected to a most critical examination, which at times should involve the use of the clinical thermometer, to detect an elevation of temperature. A vessel may arrive at a port having on board one or more unrecognized or mild cases of an infectious disease either in acute or convalescent form. These persons apparently in good health may, upon entering the town, transmit infection, but, as they are not recognized as a menace to the public, a subsequent outbreak of the disease is very apt to be attributed to infection transmitted by the ship's cargo or the clothing of those on board or from some other place.

The disinfection of ships may be discussed under two heads: First, vessels arriving with infectious disease on board; second, vessels which come from infected ports but with all on board well both at the time of embarkation, in transit, and on arrival. It is a significant fact that the number of ships treated under the second class is gradually diminishing. This is in full accord with the knowledge we now possess, which goes far to prove that infection is, as a rule, transmitted by persons, and that the danger of infection through cargoes, clothing, mail, etc., is comparatively small. The experiments which have been recently concluded in Havana by Dr. Walter Reed of the United States army, and which have furnished conclusive evidence that yellow fever is transmitted by mosquitoes, have also gone far to demonstrate that the clothing and bedding actually used by persons sick with yellow fever do not transmit infection. However, this cannot be accepted as proof that smallpox, scarlet fever, etc., are not transmitted in this way.

It sometimes happens that a serious outbreak of infectious disease occurs in a seaport town with which we are in direct communication, and where we have reason to believe the inspection of departing vessels cannot be depended upon. Under these conditions we may be justified in performing some disinfection on the ships arriving from the said place, even when no infectious disease exists on board. However, I believe that the good which comes from this extra precaution may rightly be attributed to the possible treatment of the clothing and effects of unrecognized or mild cases which may have developed in transit unknown to the ship's officer. It must be borne in mind that the master of a vessel is not a physician, and that his statement regarding the character of the sickness which may exist on board, or his opinion as to the health of the crew, should be accepted only as corroborative evidence. Furthermore, the certificate of the ship's surgeon, although given in all sincerity, must not be taken in lieu of an inspection. It has occurred in my experience that, after the captain and surgeon have stated that no sickness existed on board, a careful inspection with the use of the clinical thermometer has detected the presence of either mild cases, or cases in the early stages of some infectious disease.

The treatment and disinfection of a ship having one or more cases of infectious disease on board depends largely on the manner in which the patient has been cared for in transit, the character of the disease, etc. In a general way, it may be said that the patient must first be removed from the vessel, and those who have been exposed should also be transferred to some place where necessary disinfection can be performed, and where these people can be divided into groups and separated from each other, particularly while indoors, and kept under careful observation until the expiration of the period of incubation. Modern sanitation does not sanction the retention and treatment of either the patient or those exposed on board the vessel, if it is possible to remove them to some other place. While they remain on board proper disinfection cannot be performed. After the removal of the persons referred to, all bedding, hangings, etc., should be taken from the section of the ship occupied by the patient or patients, and if possible subjected to steam. If this is not available, it will be necessary for the sanitary officer in charge to use the best means in his power to destroy whatever infection may presumably exist. If the disease has occurred in the steerage quarters which are usually large and hold many people, either the berth occupied by the patient and those in its immediate vicinity, or the entire apartment, may be scrubbed with water and soap or washed with bichloride, 1 to 1,000. To what extent this shall be done depends upon the exposure, etc. However, in such instances we depend principally upon proper fumigation. The treatment of a forecastle, which is usually quite small and generally overcrowded and filthy, should be particularly searching, as it frequently occurs that sailors suffer from mild attacks of infectious disease which are not recognized. Therefore the appearance of a case of this character among them should be followed by thorough disinfection of the clothing and effects of all who occupy these quarters. Whether or not the disinfection shall extend to the cabin is a matter which depends entirely on the amount of exposure in each case, although in ships of large size, where strict discipline exists, there is but little communication between different sections of the vessel. If smallpox should occur in the steerage or forecastle, the disinfection of the cabin or saloon would under ordinary circumstances not be called for. If, however, cholera should appear on shipboard, we are justified in disinfecting the living apartments, clothing, bedding, water-tanks, etc., and the destruction of such provisions as may possibly have been contaminated, as in this disease there are many avenues by which its specific organism may reach the system, whereas smallpox is generally contracted by actual contact, or in some cases by infected clothing or bedding. In the fumigation of a ship great care should be observed in preparing receptacles for the generation of sulphur dioxide in order to prevent danger from fire. The immense size of the steerage quarters in some of the large ships would seem to make it more practical to use sulphur dioxide than formaldehyde.

A question which has recently been presented for serious consideration is the possible transmission of bubonic plague by rats and other vermin. It is believed that infected rats steal aboard vessels lying at docks in ports infected with bubonic plague and subsequently transmit the disease to those on board. During the prevalence of bubonic plague at Santos and Rio de Janeiro many vessels from these ports arrived at New York laden with coffee. On one of these vessels three cases of bubonic plague occurred, and it was deemed proper at that time by both the Federal and State Quarantine authorities to have the cargoes of all vessels from the said ports unloaded on lighters at quarantine in order to prevent the possible escape of rats to the mainland. During this period of four or five months, I was able to collect considerable of this vermin, which were all examined bacteriologically, but in no instance was the specific organism of bubonic plague found. The cases of bubonic plague occurring on shipboard which have come under my personal observation have been clearly traced to infection occurring prior to the departure of the vessel, and I believe that thorough investigation will prove this to be the case in almost every instance when cases of this character are found on incoming vessel. Too little attention, however, is given to the frequency of the mild or unrecognized type of bubonic plague, and I feel quite certain that the danger from rat infection on shipboard is exaggerated.

We have yet much to learn regarding disinfection, but the more it receives careful and scientific investigation, the more we find that has been improperly performed.

Alvah H. Doty.

DISLOCATIONS.—The term dislocation or luxation is used to indicate the displacement of the articular surfaces of the bones composing a joint from their normal position. This displacement may be complete or incomplete. In a complete dislocation no part of one articular surface remains in contact with any part of the other, and in an incomplete or partial dislocation the opposite surfaces are not entirely separated from each other.

Further divisions, commonly made use of, are these:—

1. Traumatic or accidental—due to force or violence.
2. Pathological or spontaneous—the result of morbid changes in the bones forming, or the soft parts surrounding, a joint. Such changes are: erosion, necrosis, softening, etc., in the one case, or paralysis of muscles or relaxation of ligaments in the other.
3. Congenital—the result of a malformation that has taken place prior to birth. It may also occur during parturition, and will then not be strictly congenital, but traumatic or accidental; although this distinction can clearly be made out only by close observation during the development of the condition.

The first division may be further divided, for practical purposes, into:

(*A*) Recent—when the dislocation has taken place within a few days or a few weeks, a sufficient time not having elapsed to produce material changes, such as result from inflammatory, exudative, or other processes, and which are likely seriously to impede reduction. Recent dislocations, it is clear, are usually reducible.

(*B*) Ancient or old—when several weeks or months have elapsed since the occurrence of the dislocation. The time which must elapse before a dislocation becomes old varies for different localities of the body and under different circumstances, but in any case it must be sufficient for such changes to have taken place as are likely seriously to interfere with the return of the bone to its proper position, or to render dangerous (to life or limb) any efforts that may be made to effect a reduction, or, finally, to render such reduction or restoration impossible—an irreducible dislocation.

A dislocation is regarded as (*a*) *simple*, when the separation of the bones is attended by only a limited or reasonable degree of injury to the soft parts, the skin retaining its continuity; as (*b*) *compound*, when the head of the bone, or a fragment thereof, has been forced through the soft parts and skin, or when in some other way an external wound communicates with the joint; as (*c*) *complicated*, when there is an extra complication, which may attend either a simple or a compound dislocation. A fracture of one or more of the bones entering a joint; laceration of important blood-vessels, nerves, muscles, integument, etc., although the wound may possibly not communicate with the joint; an extensive or serious visceral or organic lesion elsewhere in the body—all these are examples of such a complication.

Dislocations may be single, involving one joint; multiple, involving two or more joints; unilateral or bilateral; and entire, as when both extremities of a single bone, as the clavicle, or all the articular surfaces of one or more bones of the carpus or tarsus, are displaced. A bone may be at first lodged in one position—a primary or primitive dislocation; or by accident, or through the efforts made to effect a reduction, it may be removed to another position, when it is said to be a secondary or consecutive dislocation. If after a dislocation is reduced it slips back into the abnormal position formerly occupied by it, the term recurring is used. In regular dislocations certain tissues of special joints are involved; but when other than these are involved, either exclusively or in addition to those ordinarily affected, the dislocations are known as irregular.

Special dislocations are sometimes designated by the name of the joint involved, as dislocations of the shoulder, hip, elbow, etc.; more properly, however, the proximal end or ends of the distal bone or bones involved give the designation; and yet, in the case of the clavicle, it is not unusual to speak of a dislocation of the sternal or of the acromial extremity, and not of a dislocation of the clavicle alone in the one instance, and of the scapula in the other.

ETIOLOGY.—In our discussion of the predisposing causes of dislocations, we must consider, first, the forms of the various joints. Thus, for example, the shallow glenoid cavity—if such it can be called, at the shoulder-joint—is quite different from the deep cup-shaped acetabulum, although both are known as ball-and-socket joints. Under normal conditions, the ligaments which enter into the formation of the shoulder-joint—viz., the capsular, the coraco-humeral, and the glenoid—are conspicuously weaker than those which form a part of the hip-joint—viz., the capsular, ilio-femoral, cotyloid, and transverse ligaments, and the ligamentum teres; and consequently luxation can much more readily occur in the former than in the latter. Ball-and-socket joints, from their greater range of mobility, are, as a rule, more liable to luxation than ginglymoid or hinge joints. In the next place we must consider how the different component parts of a joint are altered under abnormal conditions. Thus, for example, by overstretching of the ligaments in early life undue relaxation of the latter may be produced. Such overstretching may be brought about by the abuse of the natural functions of the joint, as well as by the normal growth of the bones themselves. Relaxation of the ligaments may be congenital or it may be the result of disease, which may also produce softening of the capsule as well as of the bones. Excessive action of antagonizing muscles, and defective contractility, from paralysis or impaired nerve function, are not only to be classed as predisposing factors, but may be the direct cause. Age is unquestionably a predisposing factor, and sex has its influence. Habit, occupation, etc., also have bearings upon the question of predisposition. I quote the following from the article of Dr. E. M. Moore, in Vol. II. (p. 485) of the former edition of this HANDBOOK: "The following statistics of dislocations (*Am. Jour. Med. Sciences*, October, 1842) are so complete that we make no apology for inserting them here:

"From an examination of the register of the Hôtel-Dieu of Paris, M. Malgaigne found that, during a period of sixteen years, 530 dislocations were admitted into that institution, of which there were:

Below 5 years old	1 case.
Between 5 and 10 years	4 cases.
“ 10 “ 15 “	8 “
“ 15 “ 20 “	29 “
“ 20 “ 25 “	32 “
“ 25 “ 30 “	40 “
“ 30 “ 35 “	48 “
“ 35 “ 40 “	38 “
“ 40 “ 45 “	45 “
“ 45 “ 50 “	52 “
“ 50 “ 55 “	52 “
“ 55 “ 60 “	51 “
Between 60 and 65 years	51 cases.
“ 65 “ 70 “	42 “
“ 70 “ 75 “	19 “
“ 75 “ 80 “	13 “
“ 80 “ 90 “	4 “
At 90 years	1 case.

"Of these 530 cases, 395 occurred in males and 135 in females. Of 497 cases in which the seat of injury was particularized, there were, of the humerus, 321; clavicle, 33; elbow, 26; radius, 4; wrist, 13; thumb, 17; fingers, 7; femur, 34; knee, 6; patella, 2; foot, 20; jaw, 7; spine, 7.

"The frequency of luxations of the shoulder in elderly persons is well shown by the fact that of 164 dislocations observed in patients above the age of sixty, when the seat of injury was mentioned, 131 occurred in this part.

"The dislocations of the clavicle were principally confined to adult life; those of the elbow, on the contrary, were mostly in young persons; one-third of all cases observed being in subjects between ten and twenty; beyond fifty-four no example of it was met with. Of the 34 dislocations of the femur, 26 were in males and 8 in females."

Finally, the position of the joint at the time of dislocation is to be considered. From their position and use some joints, although stronger, are more liable to dislocation than others. Thus, for example, the ginglymoid joint of the elbow is more often dislocated than that of the hip.

Of the direct causes, we consider of first importance violence or force, whether external or internal. In most cases the dislocation results from a combination of forces, being partly the result of a blow and partly that of muscular action; yet either will suffice in some cases. Prof. Frank H. Hamilton[*] says:

"The action of certain ligaments in determining the direction of some dislocations, is also a direct cause, but only subsidiary to the other causes named.

"External violence operates either directly or indirectly. When a person falls upon the knee and dislocates the head of the femur, the force is said to have acted indirectly, and this is by far the most frequent mode of dislocation; but when the blow is received upon the upper end of the humerus, and the head is sent into the axilla, it is said to have been dislocated by direct violence.

"Muscular action produces dislocation slowly, as in severe cases of chronic rheumatism, and then it is termed a spontaneous or pathological dislocation; or suddenly, as in the violent spasmodic contractions which accompany convulsions; or sometimes by the mere voluntary effort of the muscles; and both of these latter are true accidental dislocations.

"It is very probable that external force can seldom be regarded as the sole cause of a dislocation, but that, in a large majority of cases, muscular action consenting with shock, performs an important rôle in the history of the accident. The limb, being driven obliquely across its socket by the external violence, is seized by the excited and stretched muscles with such vigor as to contribute not a little to the unfortunate result. Thus it will be found that the same force which is adequate to the production of a dislocation in the living subject is wholly insufficient to accomplish the same in the dead; and a man who is fully intoxicated seldom suffers from a dislocation."

GENERAL SYMPTOMS AND DIAGNOSIS.—The most prominent symptoms are pain and deformity; loss of normal function, as shown by impaired mobility, though in some instances we may have increased mobility; change in the length and direction of the limb; change in the natural axis of the limb with its socket; the fact that when the dislocation is reduced, the parts, if undisturbed, remain, as a rule, in position; and possibly crepitus. In some of the joints the peculiar appearance of the one injured suffices to indicate the lesion, yet the swelling from injury to the tissues, which soon arises, may alter not only these appearances but also the conditions ascertained by palpation. Immobility or other impairment of function, and pain on motion, may be marked features of certain fractures, yet when the patient is under the influence of anæsthesia, we shall often be able to discover certain peculiar differences between these cases. These differences will be noted when we come to consider the special dislocations. While there is usually lengthening of the limb, especially in downward dislocations of the shoulder and hip, yet in other instances to be mentioned there may be marked shortening; and as to the changes in direction, as well as to the retention of the parts in position after they have once been reduced, these matters require only to be mentioned at the present moment. True crepitus cannot be elicited in a simple recent dislocation; but what is known as moist crepitus, similar to the phenomenon produced by friction of a cartilaginous surface on bone, or to that produced in a case of inflamed bursæ and tendons, may often be observed. In dislocations of some days' or weeks' standing, inflammatory exudations may so roughen opposed surfaces as to produce a sensation not unlike that of crepitus; yet it ought to be possible under careful examination, and especially if the patient is put under the influence of an anæsthetic, to distinguish this sensation from the sharp, grating sound which is pathognomonic of a fracture. We must remember, however, that some fractures are not accompanied by crepitus, and these are mostly found in the vicinity of a joint; that epiphyseal fractures are attended by a more muffled or indistinct crepitus than others; and that occasionally the dislocation may be accompanied by a fracture of the head of the bone or in its immediate vicinity. It is under conditions like these that the revelations of the Roentgen or *x*-ray apparatus are of especial value. I desire to state, however, that in my experience—although in some dislocations, especially those which have existed for some length of time, I have derived great satisfaction from the use of the *x*-ray—it has signally disappointed me in those occurring at the hip. In the case of the more superficial joints, such as the elbow and wrist, or even in those in which there is a smaller amount of bony structure (the shoulder, for example), it has been of the greatest service. While in some cases we may have one or more symptoms that are really pathognomonic, we often encounter cases in which it is a very difficult matter to make a correct diagnosis. However, if the surgeon possesses a thorough knowledge of the structures which enter into the formation of the various joints, if he knows what was the condition of the limb prior to the injury, and if he makes a careful collation of the facts relating to the manner in which the injury was produced, he should be able, in recent cases, to decide upon the measures that are best adapted to afford the needed relief.

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[*] "Practical Treatise on Fractures and Dislocations," 7th American edition, 1884; H. C. Lea's Son & Co., Philadelphia.

General Pathological Considerations.—The first results of an accidental or traumatic dislocation are the rupture and tearing of the capsular and other ligamentous structures; contusion or laceration of muscles, tendons, and other adjacent tissues; and injury to blood-vessels and nerves. If an early reduction is effected, and if the joint is allowed to rest for from ten to twenty days, or even longer in some cases, the recuperative powers of nature will usually prove sufficient for the repair or restoration of all these pathological lesions. Under certain circumstances, however, a wounded blood-vessel may demand immediate ligation, or a torn nerve or ligament require suturing, either at once or at some later period. The laceration of ligaments and other soft parts, together with the rupture of even unimportant blood-vessels, will cause more or less immediate effusion of blood, and subsequently of serum. This alone, independently of the pressure of the misplaced bone and overstretched ligaments and tendons that are not torn, will, through pressure on sensitive nerves, occasion pain, of varying severity. Then, besides, the contractility of certain muscles may become impaired, either immediately after the accident or at some later date, through the injury inflicted upon the motor nerves in the vicinity of the luxation. As time goes on, if the dislocation is not reduced, other changes of a far more serious character will occur. The inflammatory exudation may become organized, and in this way the laceration in the torn capsule may possibly be closed. At the same time natural bony cavities, such as that of a ball-and-socket joint, are likely to become filled, to a greater or less extent, with exudative material. Torn ligaments and tissues become reunited in abnormal positions. Some muscles kept in too high a state of tension, and others from want of use, undergo atrophy and become impaired in their contractility. Some blood-vessels and nerves are unduly stretched, while others become contracted in their length—a matter of serious moment in the aged. Gradually changes in the bones occur, and the dislocation passes from the condition of a recent lesion to that of one which occurred a long time previously—in brief, to that of a permanent or irreducible dislocation. As to these later changes, I cannot do better than to give here the following quotation from Professor Hamilton,* which I regard as graphic and instructive:

"If the dislocation remains unreduced, the margins of the old socket, in the case of enarthrodial articulations, become gradually depressed, while the concavity of the socket is filling in with a fibrous or bony tissue, until at length the whole of this portion of the joint apparatus is nearly or entirely obliterated. This process is generally very slow, and may not be consummated until after the lapse of many years.

"At the same time, but with much greater rapidity, the head of the bone in its new position, and the soft or hard parts on which it rests, are undergoing certain changes to adapt them to their new relations, and calculated in some measure to restore the limb to its normal functions. If the head of the bone rests upon muscle, the cellular and fibrous tissues which enter into the composition of the muscle become condensed and thickened, forming a shallow or elongated cup, whose margins are attached to the neck or shaft of the bone, and whose walls are lubricated with synovia. If it rests upon bone, by a process of interstitial absorption a true socket is formed, sometimes deep, and sometimes shallow, whose edges, receiving additional ossific depositions, become lifted so as to form a rim. At the same time the head of the bone is undergoing corresponding changes, to adapt itself to the newly formed socket; it is flattened or otherwise changed in form, and in the progress of this change its natural secreting and cartilaginous surfaces are gradually removed, a porcelaineous deposit taking its place. The same kind of hard, polished, ivory-like deposit is found also in those portions of the new socket which have been especially exposed to pressure and friction. Instead of the eburnation, an imperfect fibro-serous surface or synovial capsule may be formed."

"I have in my cabinet," he says, "an example of ancient luxation of the hip-joint in which the head of the femur, having rested upon the dorsum ilii, has formed a nearly flat but smooth surface—a kind of elevated plateau; in other cases I have seen the margins of the new socket so elevated as to rest against the neck of the femur, and completely lock it in.

"Coincident with these changes, and in consequence partly of the disuse of the limb, the muscles, and even the bones sometimes, suffer a gradual atrophy. In some measure these alterations may be due also to the pressure of the dislocated bone upon arterial and nervous trunks, by which their functions become partially or completely annihilated, and their structure may be wholly obliterated. In consequence also of the inflammation which immediately results, we ought not to omit to notice that the trunk of a large artery sometimes becomes firmly adherent to the capsule or periosteum of a displaced bone, and its reduction is attended with imminent danger of laceration and of a fatal hemorrhage. Numerous instances of this grave accident, especially in attempts to reduce old dislocations of the shoulder-joint, are upon record."

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* *Op. cit.*, p. 633.

This quotation from a master in this special line of work is so in consonance with my own views and observations, and has such an important bearing on the prognosis and treatment of luxations, that I feel no hesitation in reproducing it in this place.

In those cases in which a dislocation of a ginglymoid or hinge joint is not early reduced, the bones may accommodate themselves more or less satisfactorily to the changed relations, and motion more or less practical may be regained, but the comparative restoration of function is never, or at least very rarely, so satisfactory as that of the ball-and-socket joint.

The degree of disturbance is not so marked in spontaneous or pathological dislocations as it is in those of the traumatic variety; the capsule and other ligaments may be stretched only, and not torn; the lesions of other structures are not necessarily present; and if the material changes above-mentioned do result, they are later in developing. In compound dislocations, all those additional lesions which may characterize a compound fracture—the result of suppuration or other action caused by contamination from without—are, as a rule, intensified. If complications exist, their nature, and the possibility that they may produce features of greater importance than the dislocation itself, or perhaps even a fatal termination, must be carefully and thoroughly considered.

General Prognosis.—As in dislocations so much depends on the character of the particular joint involved, this subject will to a great extent be left for subsequent consideration. I may state, however, that in recent dislocations restoration of function, more or less complete, may be confidently expected when the reduction has been successfully effected, and when the proper after-treatment has been carried out; yet it is but proper to state that very few joints, after they have once been completely displaced, are ever perfectly restored. They are not only more prone to undergo subsequent dislocation when subjected to a smaller degree of force, but they are apt, for a period of many years or even during the life of the individual, to manifest other sequelæ of the original accident—such, for example, as a partial defect of mobility, diminished size and power of the muscles, and more or less pain. This latter symptom may be persistent in character or it may recur from time to time, these characteristics depending to some extent on the joint injured, on the nature of the injury, on the length of time which has elapsed between the receipt of the injury and the reduction of the dislocation, on the means employed in effecting the latter, on the subsequent condition of the patient, and on various other conditions peculiar to the joint involved. As a rule, we can never promise as satisfactory a result as we can in a case of fracture of like character.

The possibility of malpractice suits must not be lost sight of. Dislocations are almost as fruitful a source of such annoyance as fractures; possibly they are even more so. We have the usual history of a dislocation with swelling either before or after reduction. The patient is possibly informed that an early recovery may be looked for, with perfect usefulness of the limb. After the pain and swelling subside, there is much surprise, on the part of the patient, at his increasing inability to use the limb —*e.g.*, the hand and forearm in shoulder luxations, and the foot and leg in those of the hip,—and soon well-marked symptoms of muscular atrophy may develop. Accompanying the injury there has perhaps been a contusion of one or more nerves or plexuses, and in consequence of this a peripheral neuritis develops, the symptoms of which are obscured by those necessarily attending the dislocation itself. The prognosis which was given by the surgeon is not fulfilled, and the early recovery promised does not take place. As a result, the patient, naturally disappointed after months of invalidism, and possibly in more or less suffering, eventually becomes convinced by some means or other that he is permanently disabled. The idea takes possession of him that a surgeon who has been so incorrect in his prognosis must have been deficient in the matter of treatment, and a suit for malpractice is regularly instituted.

The possibility of nerve injury should never be lost sight of in any important dislocation. In some cases it may be accompanied by a paralysis which manifests itself immediately after the inception of the injury. In other cases the paralysis does not develop until later. At first there may be only a slight numbness or tingling, the paralysis due to the neuritis coming on several days, or one or two weeks, or even a longer period, after the bone has been replaced. Before giving a definite prognosis the nerve supply should be carefully studied—if necessary, for a period of several days, or even for a week or more. During this time both sensation and motion should be carefully tested, and some form of electric stimulus should be employed if the least doubt or uncertainty remains.

Drs. Keen and White* say that: "In uncomplicated cases reduction is habitually followed by repair of the torn capsule and ligaments, but complete restitution to the normal condition may be prevented by faulty repair of some of the lesions, by peri-articular thickening, by subperiosteal formation of bone in the young, or by more or less thickening of the joint. Thus, at the shoulder, the ruptured tendon of the supraspinatus and the upper part of the capsule may fail to reunite, and the patient be thereby exposed to frequent recurrence of the dislocation. . . . At the elbow, the stripping up of the periosteum from the posterior aspect of the external condyle may lead to such thickening of the bone as will limit extension." These, with other features of special prognostic importance, will receive due attention further along in this article.

General Treatment.—It is now the accepted rule that recent dislocations should be reduced, or the parts restored to their normal position, at the earliest possible moment. Ease of reduction and diminution of pathological factors demand this. However, contingencies may arise, such as great inflammatory reaction and swelling, extreme shock, etc., that may justify a delay for a few hours or days. Shock, if not too profound, may aid in the immediate reduction by causing relaxation of opposing tissues and freedom from pain; yet extreme shock demands consideration just as much as do the associated injuries.

At the present day, manipulations made by the surgeon, either alone or aided by assistants, usually suffice for the reduction of a recent dislocation. These manipulations consist in a succession of gentle but firm movements communicated to the limb, by means of which the head of the bone is enabled, with the aid of the untorn ligaments, to re-enter the torn capsule and be rolled or slipped back into its position. In the carrying out of this procedure the tension of opposing muscles is relaxed and the contraction of others is increased. In rare instances it will be found necessary to resort to mechanical appliances and to employ an anæsthetic, the necessity for their use becoming more urgent, or possibly even imperative, the longer the dislocation remains unreduced. Manipulation is regarded by some as only applicable to typical or regular dislocations, but by the exercise of care irregular luxations can first be converted into regular, and then they may be reduced by the method just mentioned. Kocher's method of reducing anterior dislocations of the shoulder, and that employed by Prof. Nathan Smith in dorsal dislocations of the hip—both of them now regarded as classical—are typical illustrations of manipulative methods.

Occasionally, spontaneous or pathological dislocations are restored by the unaided movements of the patient, and even accidental or traumatic dislocations have been reduced by another accident. In quite a number of recent American medical journals of recognized trustworthiness a case was reported in which a man received a dislocation of the shoulder. He was placed in an ambulance, for removal to a hospital, by an interne who recognized the true character of the injury. On the way the horse became frightened and ran away, turning the vehicle over. When the patient was examined after this last accident it was found that the dislocation had been reduced by the fall.

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* "American Text-book of Surgery," p. 425; W. B. Saunders, publisher, Philadelphia, 1900.

I have already stated, in an earlier part of this article, that it is important for the surgeon to possess a complete and thorough knowledge of the structures entering into the formation of a joint. I deem this matter, however, to be of such importance that I now repeat the statement. Any one may, in certain instances, have the good fortune to succeed in reducing a dislocation, but if the medical man, after the employment of firm but gentle movements, with a strict avoidance of force or of anything like violent tugging at or twisting of the limb, fails to reduce the dislocation, it is far better that he should desist from further attempts until skilled technical aid can be obtained; and the same advice may be given with equal propriety to the physician or surgeon who does not possess a satisfactory knowledge of the joint involved. It is far better, both for him and for the patient, that other than the simplest efforts be deferred until such skilled assistance can be secured.

As regards the preliminary steps needed for the reduction of a dislocated joint, they may be stated as follows:

The joint and the limb should be properly exposed and the patient should be placed on a good, firm table, with one or two cotton quilts, or comforters, or blankets under him; these being preferable even to a mattress, unless it should be a thin or somewhat firm one. Even the floor or the ground prepared as above is preferable to the yielding surface and other inconveniences of a bed.

If the injury involves one of the larger joints, or if the patient's muscular development is far in excess of that of the surgeon, or if he is extremely nervous and is suffering from acute pain—the first slight shock which to some extent not only temporarily paralyzes the muscular structures but also obtunds the pain, having passed off—the use of an anæsthetic will be found of great service in establishing a correct diagnosis as well as in effecting the reduction of the dislocation. From the greater safety of ether, I rely upon it, as a rule, rather than upon chloroform; yet if the patient is either very young or of advanced age, or if there is any history of pulmonary or renal disease—which should always, if possible, be ascertained before the use of any anæsthetic—I prefer the latter more powerful agent. In a simple case, in which the diagnosis is free from all doubt, if nervousness and acute pain are the only factors to be overcome, the primary anæsthesia with ether, as first suggested by Dr. Addinell Hewson, may be all that is necessary; but if it be found that the local conditions are not so favorable as they often are, or if the patient is extremely nervous, feeble, or diseased, and especially if he be suffering greatly from shock, the anæsthesia should be pushed beyond the primary stage in order that complete relaxation may be secured before efforts at reduction are made.

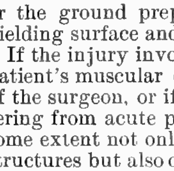

FIG. 1598.—Clove Hitch.*

If the reduction is essayed without an anæsthetic, it is a good plan to keep up conversation on irrelevant topics during the examination and preparatory movements for reduction, thus diverting the patient's thoughts from the injury and from the preparations that are being made to relieve it. A short, sharp interrogatory or exclamation, made at the moment of greatest effort, has in many instances been of material aid in preventing or diminishing the contraction of antagonizing muscles.

While a certain degree of force is required in many instances, and the movements must sometimes be made in a quick or sudden manner, we should bear in mind that violence is never to be resorted to in recent dislocations. Relatively, the force exerted should not be more than the weight of the limb if separated from the body. The untorn part of the capsule and the other ligaments being already under a marked degree of tension, and certain muscles being in a state of contraction, our aim should be to slip the head of the bone over bony prominences and back through the rent in the capsule in much the same manner as we would slip a button into a button hole. Beyond this our efforts should not go; and while they may be exerted with firmness and at times with rapidity, they should be gentle and not violent.

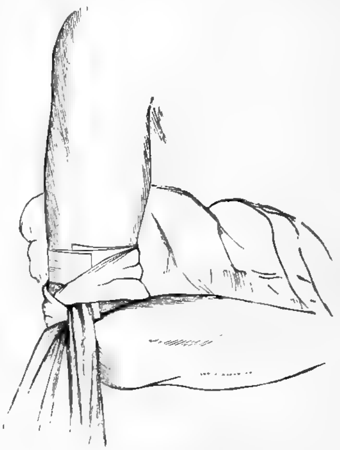

FIG. 1599.—Clove Hitch as Applied to the Humerus, with Bandage Underneath.

In cases in which reduction is prevented by the interposition of a part of the capsule, or by the presence of other tissues, such as a muscle or a tendon, an open arthrotomy may be required; and this step may be necessary even in the case of larger joints. When proper aseptic precautions are taken, the operation is reasonably safe, provided it is undertaken on or before the second day after the injury; but after this date we should wait until the third or the fourth week—*i.e.*, until after reaction and inflammatory fever have subsided, and until the extravasated blood and serum have to some extent been reabsorbed—before we attempt so serious a procedure.

In the event of failure by manipulation, and in the case of ancient or old dislocations, it will be found necessary to resort to extension and counter-extension, to be made by our hands and by those of assistants; and, in a few cases, mechanical appliances will be required. In the first instance the surgeon, taking hold of the limb firmly with his hands, makes the extension, while the counter-extension is maintained by his assistants; or, in some cases, both are made by assistants, and the surgeon simply manipulates the parts with his hands or fingers, or makes direct pressure on the bone in a proper direction. Finally, by employing his knee or his foot, as well as his hands, the surgeon can carry out both extension and counter-extension without the aid of an assistant. In order to make extension various contrivances may be required. Such are: a folded bandage or handkerchief forming a clove hitch (Fig. 1599) around the limb; the toy made of braided ash splittings known as the Indian puzzle; Levis' splint; Luer's or Charrière's forceps for the finger, etc. In order to apply the extending force effectively, broad strips of strong adhesive plaster should be attached along the anterior, posterior, and lateral surfaces of the previously shaved limb. They should be carefully adjusted and then they should be covered with a roller bandage, drawn moderately tight and forming loops which, in the case of shoulder, elbow, and hip dislocations, should extend beyond the extremity. Counter extension should be made by means of a folded sheet or towel placed in the axilla or perineum and firmly fixed or held there; or the shoulders or the pelvis may be kept immovable by means of properly padded straps that are fastened to the table or floor.

In ancient or old dislocations it is necessary first to break up those adhesions which keep the bone bound down in its abnormal position. This may be accomplished by simple manipulations, or it may be necessary in some cases to resort to subcutaneous section or even to arthrotomy. In all these cases the employment of a general anæsthetic is imperative. If the manipulative efforts of the physician or attendants do not suffice, extension may be made by means either of the compound pulleys or of the Spanish windlass. The latter is made by taking a piece of strong cord or light rope of sufficient length, securing the ends (one to the limb and the other to some immovable object), forming a loop of two or of four thicknesses, placing a stick between the two single portions or two portions of two each, as the case may be, and then twisting the bundle of these portions of rope until the necessary degree of shortening is obtained. An ordinary Petit's tourniquet may supply the extending force, and Jarvis' adjuster is an old mechanical device that has its advantages for certain cases. A continuous extending force, which tends to overcome the contraction of the muscles and tendons, may be obtained by means of the weight and pulley, or by an elastic cord, or even by the mere weight of the limb alone, that of the body serving for counter extension.

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* This and several other illustrations which appear in the present article were prepared from drawings furnished by Dr. Edward M. Moore, of Rochester, N. Y., for publication with the text which he wrote on this same subject fifteen years ago. (See Ref. Handbook, Vol. II., 1st edition.)

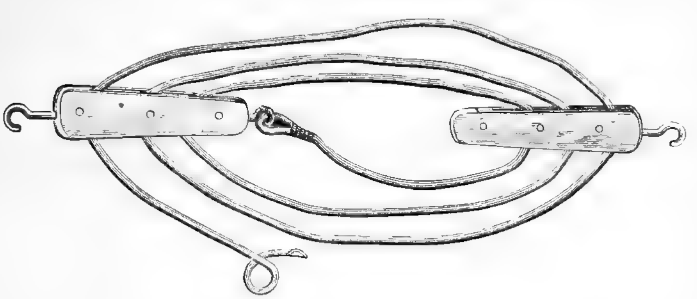

FIG. 1600.—Triple Pulley.

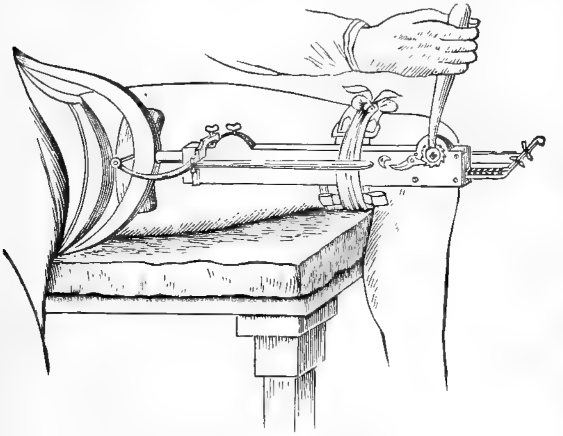

FIG. 1601.—Jarvis' Adjuster.

An easy method of reducing dislocations of the shoulder and hip has been suggested by Dr. Lewis A. Stimson in the New York *Medical Record*, of March 3d, 1900. It is described by him as follows:

"The patient upon a canvas cot, with the injured arm hanging through a round hole made in the middle and about eighteen inches from the end. The cot is raised to a sufficient height from the floor, and a ten-pound weight is fastened to the wrist of the dependent arm. Reduction is accomplished in a few minutes and without pain. It has been tried in ten cases, and has never failed, six minutes being the longest time required.

"In dorsal dislocations of the hip the patient is placed prone upon a table, with thighs extending beyond its end. The uninjured thigh is held horizontal, to prevent tilting of the pelvis. With the injured thigh vertical, and leg at a right angle to it, the surgeon grasps the ankle and gently moves it from side to side, perhaps making gentle pressure downward at the knee. If relaxation is slow to appear a sand-bag weighing five or ten pounds may be placed in the popliteal space to produce more traction. This simple procedure has succeeded in reducing the dislocation in more than four-fifths of the cases, and often without anæsthesia. In the two cases failing by this method, reduction was accomplished by traction in a line midway between right-angled flexion and full extension. In these cases the bone had probably left the socket at a higher point."

When it is necessary to resort to mechanical force or even to manipulations, in dislocations either recent or old, the surgeon must not lose sight of the fact of the possibility of injuring the patient by fracturing the bone or by lacerating or bruising the soft parts, especially the arteries and nerves. As a rule, the amount of force is to be determined by the surgeon in accordance with both the local and the general conditions observed in each individual case; good common sense and correct judgment must be his guide. While the serious accidents mentioned above have happened in the hands of some of the ablest surgeons, they are to be avoided rather than excused.

In simple dislocations the after-treatment consists in keeping the joint at rest for a variable length of time according to the joint involved, from ten days to two or three weeks usually sufficing; at the end of which time passive movements are carefully to be resorted to for several days, and then the patient may be permitted gradually and cautiously to resume the use of the joint. In some joints, as the clavicular, special dressings are essential, but ordinarily a sling for the arm, or a carefully adjusted bandage or other temporary support for a few days, is all that will be required. Compound and complicated dislocations require not only a longer time for

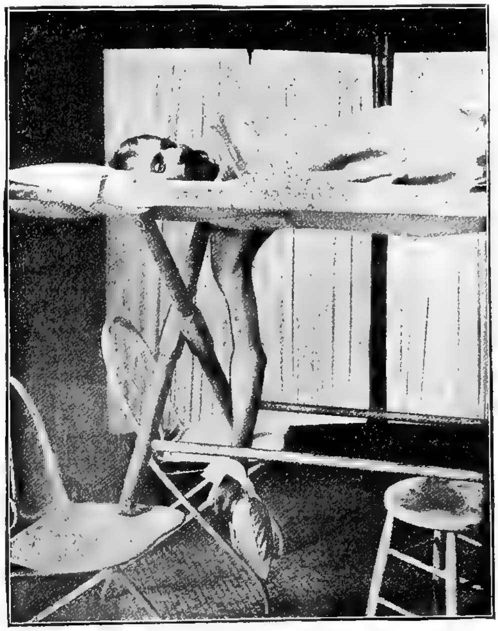

FIG. 1602.—Stimson's Method of Reducing a Dislocation of the Shoulder.

recovery, but, in addition, the special treatment indicated by correct surgical technique for the particular condition that may be present.

SPECIAL DISLOCATIONS.

Dislocations of the Spine.—As these occur so rarely unaccompanied by fracture of some portion of a vertebra that enters into the formation of the joint, their consideration will be found in the article entitled *Spine, Surgery of the.*

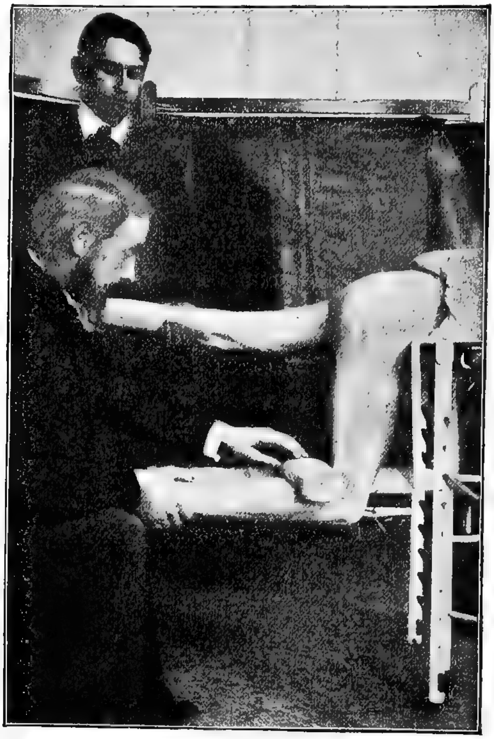

FIG. 1603.—Stimson's Method of Reducing Dislocations of the Hip.

Dislocations of the Ribs, always the result of direct violence, may take place at their junctions with the vertebræ, the sternum, or the cartilaginous extensions. A fracture, however, is the more common occurrence; the differential diagnosis between the two conditions being, in many cases, very difficult to establish, if not actually unattainable. If the vertebral extremity is involved, but little can be done toward reduction. We may apply to the neighboring skin strips of adhesive plaster (perforated in the same manner as is a porous plaster), and then furnish the additional support of a well-applied and carefully adjusted bandage, to keep the parts at rest as much as possible. This is about all that can be done. If the displacement is outward, a compress may be needed in addition. Persistent pain more frequently results after a dislocation than after a fracture, and the possibility of resection of the head of the bone for its relief may have to be considered. In inward dislocation of the sternal end, keeping the shoulders well thrown back by an ordinary shoulder brace, properly fitted with adhesive plaster placed over the rib in the manner described above, will accomplish the most satisfactory results. If the dislocation is outward, the need of a compress and bandage will naturally suggest itself.

Dislocations of the Lower Maxilla are comparatively rare. They constitute about four per cent. of all dislocations, being most common in males and most rare in childhood. They may be complete or partial, unilateral or bilateral, the former being by far the most frequent. Congenital dislocations are almost unknown. A predisposition may be furnished by a shallow glenoid cavity, the eminences being unusually low, or by relaxation of the ligaments, the result of disease or of fatigue. Independently of any such predisposition, the direct causes are violence by blows or falls upon the chin, the mouth being open; over-wide opening of the mouth in gaping or hallooing; biting upon hard substances, etc. In the over-fatigue and relaxation of the muscles of the jaw incident to prolonged dental operations, a sudden movement on the part of the operator or patient, and even the spasmodic contraction of the muscles of the jaw, have occasionally produced this form of dislocation. When the jaw is greatly depressed, the condyles move forward, carrying with them the interarticular cartilages; then they break through the capsular ligament and, gliding over the eminences, are drawn away from their articular surfaces by the action of the external pterygoid, the temporal, and the masseter muscles.

Symptoms.—In bilateral dislocation the mouth will be found open and fixed, the lower teeth projecting beyond the upper, the chin prominent, and the patient in great pain. The glenoid cavity is empty, and the locality is marked by a depression; the coronoid process and the tendon of the temporal muscle causing a prominence just behind the malar bone. In unilateral dislocation, the jaw is drawn to the sound side, giving the lower part of the face a twisted appearance; the jaws are somewhat separated and fixed; the mouth is partially open; and a depression is found in front of the ear on the injured side, with a prominence at the corresponding point on the opposite side. The lower molars project beyond the upper ones on the sound side, while on the other side the upper ones are external to the lower; the incisor teeth of the lower jaw project beyond those of the upper jaw and are carried toward the sound side. Dislocation is differentiated from fracture by the absence of crepitus, by the immobility of the jaw in the former condition, and by the prominence which a fragment of bone would cause below the zygomatic line in the latter. Further-

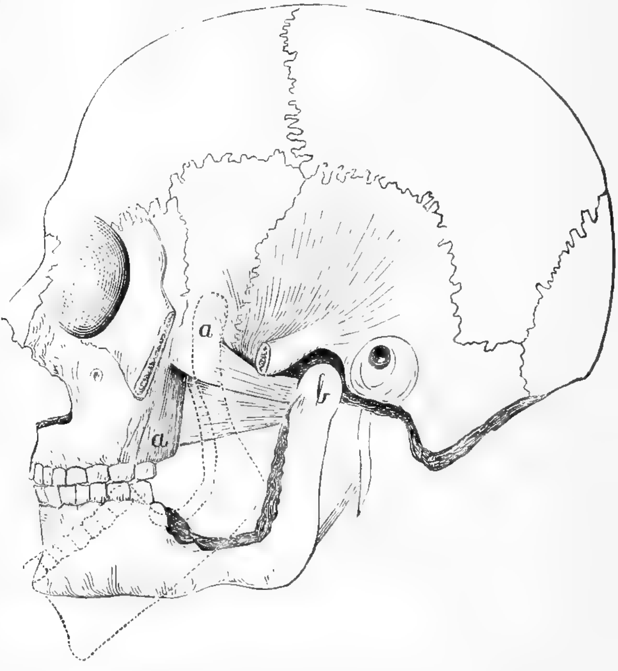

FIG. 1604.—Action of External Pterygoid Muscle (*a, b, a,*) in Dislocation of Lower Jaw; the Dotted Line Shows Position of Bone when Displaced.

more, the chin is drawn toward the injured side in unilateral fracture.

Treatment.—If the dislocation is of recent occurrence, the patient should be seated in a chair while the surgeon stands in front of him. Having protected his thumbs by several thicknesses of bandage, by stout leather thumb stalls, or by leather gloves, to prevent injury to them by the involuntary closure of the jaws while reduction is being accomplished, the surgeon should pass them well back over the molar teeth of both sides, the jaw being firmly grasped by the fingers under the chin as it rests in the palms of the hands. Using the thumbs as a fulcrum, he should press firmly first downward and then slightly backward on the molars, the chin at the same time being elevated as a lever. In this manner, and with the aid afforded by the temporal and masseter muscles, he will probably be able to restore the condyle or condyles to their natural position. When these slip into position, usually with an audible sound, the surgeon removes his thumbs laterally to prevent their being bitten. Dislocations of some weeks' standing have been reduced by manipulation and without an anæsthetic. If the patient is compelled to occupy a recumbent position, the surgeon will find his most suitable position to be on his knees, astride the patient's chest, or on his knees at the patient's head, the position of his hands being reversed. The head should, in all cases, be firmly fixed by a strong assistant. The discomforts and inconveniences of a dislocation of the jaw are so great that they are rarely permitted to become ancient; but in such event, or if reduction is found difficult or apparently impossible by reason of muscular rigidity and contractions, or on account of the patient's timidity or for other valid reasons, I do not hesitate to use the proper anæsthetic, the patient being placed in the recumbent position and proper precautions being taken. In some instances wooden levers, or a strong-bladed knife, or a thin chisel may be needed to depress the condyles while the chin is being elevated.

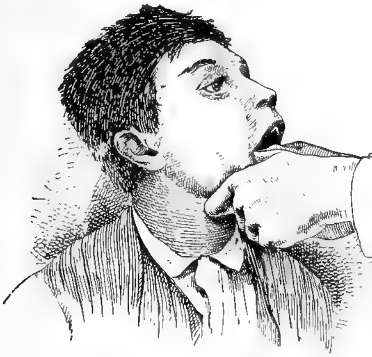

FIG. 1605.—Method of Reduction of Dislocation of the Lower Jaw. (Helferich.)

In partial dislocations or subluxations, which are sometimes habitual and which are indicated by sudden immobility of the jaw, by a slight separation of the incisors, and by inability to approximate the teeth, the accident usually comes on while the patient is chewing or biting some hard substance. In this form of dislocation the articular surfaces do not leave the glenoid cavity; the interarticular cartilages merely slip behind the condyles and become fixed on the articular eminences. Under such conditions, therefore, it is usually an easy matter to effect a reduction by pressing with the fingers downward and backward on the coronoid processes, or by introducing a narrow wooden wedge or the blade of a dull table knife between the teeth and prying them open.

The after-treatment consists in applying a roller bandage, Barton's, a four-tailed bandage, or a mento-cervico-occipital cravat or bandage to prevent or somewhat restrict the movements of the lower jaw for about ten days or two weeks, by which time the rent in the capsule will be closed. At the same time it is well to restrict the patient to fluid or semi-fluid diet, and he should be cautioned as to the movements of the jaw during this time and for some weeks after the dressing has been removed. Recurrence is by no means uncommon in luxation of the jaw. In one case, a hysterical female, I was required to reduce a bilateral dislocation seven times in thirty-three days.

Occasionally, from too great laxity of the ligaments of the lower jaw, during ordinary movements, the condyles slip forward on the articular eminences when the mouth is opened, and then as suddenly slip back, producing a slight noise as the mouth is closed. Drs. Wharton and Curtis in their recent work* mention the injection of a few drops of absolute alcohol into the ligaments as having been practised with success.

Dislocations of the Hyoid Bone are so rare that nearly all surgical works ignore them. Hamilton, in his very complete work, limits himself to quoting the two cases from Holmes' "Surgery" and the summary of the papers of Dr. Ripley of South Carolina and of Dr. Gibbs of London. Stimson's monograph on dislocations does not mention this bone, and Dr. Moore's article, in the preceding edition of this HANDBOOK, gives the report of a single case which came under his observation. It also quotes the cases that are referred to in Holmes' "Surgery." In the case of the young man who was seen by Dr. Moore, it appears that he had always been able to restore the position of the bone except on one occasion. Ordinarily, he accomplished the reduction by bending the head forward and in the opposite direction from that in which the dislocation had occurred, and then rubbing the part. On the exceptional occasion referred to, it was found necessary to employ the suspension apparatus ordinarily used for applying a plaster-of-Paris jacket. When the suspension had been pushed so far that the patient was obliged to rest upon the tips of his toes, the bone suddenly snapped back into place.

Dislocations of the Sternum, although considered as such by many authors, scarcely deserve the name. While the union between the ensiform process and the middle portion or meso-sternum does not take place until old age, and that between the meso-sternum and pre-sternum or manubrium not until after the fortieth year, the points of junction present scarcely any of the characteristics of a joint at any time, the movements being limited to the resiliency of the cartilaginous junction. However, we do in rare instances have displacements of the upper and lower portions from the middle. As a rule, these are the results of direct violence, and the injury partakes more of the nature of a fracture (resembling an epiphyseal fracture) than of a true luxation.

The displacement of the manubrium may be either forward or backward, the costal cartilages retaining their attachments; and with the displacement may be associated a fracture of the upper ribs or their cartilages.

The Symptoms are, projection of the lower portion of the manubrium upon the anterior surface of the chest in a forward displacement, and of the upper portion of the meso-sternum if the manubrium is displaced backward; either of which alterations will be quite apparent from the limited amount of the tissues which cover the sternum at these points. Usually, the respiration is somewhat embarrassed, and there is pain, especially with the respiratory movements.

Treatment.—After the patient has been anæsthetized—if there are no contraindications to the use of an anæsthetic—the trunk should be flexed or extended and at the same time direct pressure should be made over the projecting portion of the sternum. In some cases a successful reduction may be obtained by these measures. No violent attempts, however, should be made, as the pain will in a few days disappear under rest, and recovery may be expected, although some deformity will remain.

The ensiform portion is occasionally displaced backward by a direct and sudden force applied over the epigastrium. Ocular inspection with palpation suffices to indicate the displacement, which may be accompanied by pain in the stomach, and occasionally by vomiting and labored or painful respiration. If reduction cannot be accomplished by passing the fingers below the ensiform cartilage and pushing it forward, an incision may be made under rigid asepsis, and the process drawn into position with one or two tenacula. The suggestion of Drs. Wharton and Curtis,* to excise the process, if the failure to effect a reduction should be followed by troublesome symptoms, is worthy of consideration.

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* "Practice of Surgery," by Henry R. Wharton, M.D., and B. Farquhar Curtis, M.D., p. 560, revised edition, 1900; J. B. Lippincott & Co., Philadelphia.

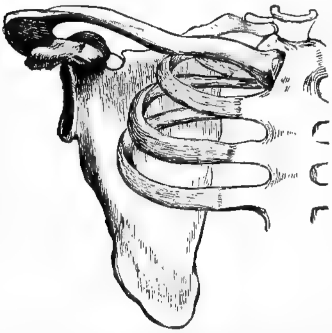

FIG. 1606.—Luxation of Sternal Extremity of the Clavicle.

Dislocations of the Clavicle may occur at either end, the sternal or the acromial. If the usual custom as to dislocations in general were followed, a dislocation of the acromial end of the clavicle would more properly be designated as a dislocation of the scapula, but the term now used is so well established as to make it difficult to change it. These dislocations are usually single, yet Hamilton † cites a very interesting case of a double dislocation; and while it may be "entire"—both ends of one bone being displaced at the same time—this is so very rare as not to necessitate consideration here.

"Of 57 dislocations of the clavicle"—says Professor Hamilton, in his introductory paragraph to this subject—"observed and recorded by me, 13 belonged to the sternal end and 44 to the acromial. Of those belonging to the sternal end, 11 were dislocations forward, forward and upward, or forward and downward, and 2 were upward. I have never met with a dislocation backward. Of the acromial dislocations the whole number were dislocations upward, or upward and outward."

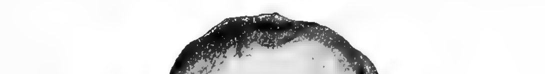

FIG. 1607.—Forward Dislocation of Sternal end of Clavicle. (Helferich.)

The sternal end is usually thrown forward by a fall on the outer surface of the shoulder, in which event, as the force comes upon the anterior and outer surface of the shoulder, the clavicle is driven inward toward the median line and glides up on to the face of the manubrium, while the leverage exerted backward upon the acromial end tears loose the attachments of the opposite extremity. A direct force sufficient to drive the sternal end backward is more likely to result in fracture at or near the point of impact.

In dislocation of the sternal end forward, even in fleshy individuals, the head of the bone can be distinctly felt and seen lying on the front of the sternum, the shoulder on that side falling slightly back, and the head inclining slightly to that side, through traction on the muscles attached to the clavicle. The attachment of the sterno-cleido-mastoid muscle to the clavicle is sharply defined, and by measurement the acromion can be shown to be nearer to the median line of the sternum. At the same time the movements of the arm are embarrassed, and there is acute pain at the site of the luxation. If the shoulder is elevated the head of the bone overlying the sternum will descend; if, on the other hand, it is depressed, the head of the bone will rise, and by drawing the shoulder back, the deformity may be made to disappear or at least to become less noticeable. A tumor of the head of the bone or the presence of some other hyperplasia may mislead, and we must be on our guard not to overlook a fracture near the sternal end of the bone.

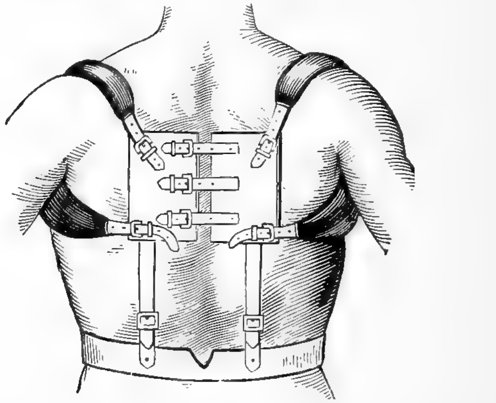

FIG. 1608.—Sir Astley Cooper's Apparatus for Dislocated Clavicle.

This variety of dislocation of the clavicle, though easy of reduction, is difficult if not impossible to maintain in the position of reduction. Hamilton says that in not a single one of the eleven forward dislocations seen by him was the treatment successful. Stimson is equally unfavorable as to complete correction of the deformity; and Wharton and Curtis* say: "The prognosis is unfavorable as regards complete correction of the deformity, but favorable in respect to the restoration of function."

Reduction is effected by drawing the shoulder outward and slightly backward, pressure being made at the same time directly backward on the head of the bone as it is brought opposite the joint. For maintaining it in this position for the five or six weeks required for complete repair of the injured tissues, a variety of expedients have been suggested. A figure-of-8 bandage with a firm compress over the head of the bone; Récamier's dressing for fractured clavicle; Sir Astley Cooper's apparatus aided by direct pressure over the head of the bone; the application of a plaster-of-Paris dressing according to the principles advised for reduction; and even keeping the patient in the horizontal decubitus for the necessary period of six or eight weeks—all these have been tried and have proven ineffectual. My preference is for a carefully applied figure-of-8 bandage, with compression over the head of the bone, to be maintained for six or seven weeks, and with the elbow secured in proper position by means of a sling and bandage confining the arm to the chest. I believe that this plan of treatment will afford the greatest certainty of restoring a fair degree of functional activity while at the same time fulfilling the other indications and contraindications. In the case of a young female, we might be justified, for the sake of preventing any deformity, in keeping the patient on her back for the necessary length of time, her general condition being carefully watched during this period.

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* *Op. cit.*, p. 561.

† *Op. cit.*, p. 661.

* *Op. cit.*, p. 176.

Backward dislocations may be produced by a direct force acting near the sternal end, but not of sufficient strength to produce a fracture; or they may result from a force acting indirectly upon the posterior and outer surface of the shoulder. In this form of dislocation the end of the clavicle may be found below and behind the sternum or slightly above it; the shoulder may drop forward, and the displaced end of the bone may press upon the trachea or upon the œsophagus, thus producing dyspnœa or dysphagia, together with pain more or less severe in the locality. In some instances there may also be a partial arrest of the circulation in the arm, due to pressure on the subclavian artery.

In order to effect a reduction the shoulder must be carried upward, outward, and backward, and the parts may then best be maintained in this position by keeping the patient on the back with a firm cushion beneath the shoulders; or a bandage may be applied in the manner suggested for the relief of a dislocation of the clavicle forward—no compress, however, being needed. This form of dislocation is not only readily reduced, but the parts can more easily be maintained in the desired position than in the case of the other variety. The restoration of function may be complete, although some deformity is likely to remain.

Dislocation upward of the sternal end of the clavicle is almost universally produced by a force operating on the end and top of the shoulder, throwing it inward and downward and causing the inner extremity of the clavicle to be torn from its attachments by the leverage exerted from the acromial end. When such an accident happens, not only the capsule with the ligaments closely investing it, but in some instances the costo-clavicular ligament and some fibres of the subclavian muscle are ruptured. In this form of dislocation the shoulder appears to be depressed, and the sternal end of the clavicle is so lifted as markedly to increase the space between it and the first rib. The suprasternal fossa is encroached upon, there is a diminution of the acromio-sternal distance, and the head of the bone, protruding between the sternal attachments of the sterno-cleido-mastoid and the sterno-hyoid muscles, may pass beyond the middle of the sternum and may overlie the sterno-clavicular junction of the opposite side. The sternal portions of the sterno-cleido-mastoid muscles on both sides may be raised and rendered tense by the pressure of the bone from behind.

"Reduction may be found easy," says Hamilton, "but Malgaigne thinks a perfect result is impossible—at least it does not seem to have been accomplished in any of the cases reported." Yet farther on he says: "In no case did the displacement seriously impair the functions of the arm."

In the Treatment of this variety of dislocation the arm should be drawn upward and outward, while at the same time the head of the clavicle is pressed down into the articular cavity. Maintenance is secured by drawing the shoulder back with a figure-of-8 bandage, placing a heavy compress in the axilla, and securing the elbow to the chest. As a further aid, a compress should be placed over the head of the bone, and upon this there should be brought to bear a force acting in a downward direction. If these measures fail, and if the necessities of the case demand it, from either a functional or a cosmetic standpoint, the joint may be opened and the head of the bone strongly wired to the sternum.

An important point to be considered in these dislocations is the strong necessity of preventing movement of the dislocated end of the bone,—a task which is rendered specially difficult by the nature and position of the joint and by the constant movements of the body and arm. Furthermore, if the case is one in which the question of deformity may be set aside, it is better to aim at securing the restoration of a reasonable degree of functional activity and not to undertake too heroic or violent measures for relief. As a rule, all efforts to secure reduction of the dislocation should be limited to a quite early period, and the danger of injuring important subjacent tissues and vessels must be kept constantly in view.

In dislocations of the acromial end of the clavicle, it is deemed necessary to consider only three varieties, viz., one in which the end of the clavicle is lodged above the acromion, or upward; another below it, or downward; and the third, below the acromion and coracoid processes —the subcoracoid variety of dislocation of the clavicle.

In upward dislocation we find drooping of the shoulder and a prominence produced by the end of the clavicle projecting above the acromion. With these conditions are associated pain and a greater or less degree of difficulty in using the arm. The dislocation may result from "force acting directly upon either the scapula or the clavicle," as happens very frequently.

The reduction is usually effected quite readily by pushing the head of the humerus upward, and at the same time making downward and slightly lateral pressure on the end of the clavicle. If the dislocation has taken place in an outward direction, the shoulder should be carried well backward, or outward and backward; or a pad should be placed in the axilla and the arm should be used as a lever, proper pressure being made at the same time upon the displaced end of the clavicle.

The maintenance of the joint in its natural position, after reduction, is a more difficult task to accomplish, owing to the fact that the weight of the arm, acting in conjunction with the contraction of muscles, drags the shoulder down, while at the same time the contraction of the trapezius lifts the clavicle up. A variety of suggestions have been made as to how the purpose desired may be accomplished. Among them may be mentioned the following: most of the dressings used to correct fracture

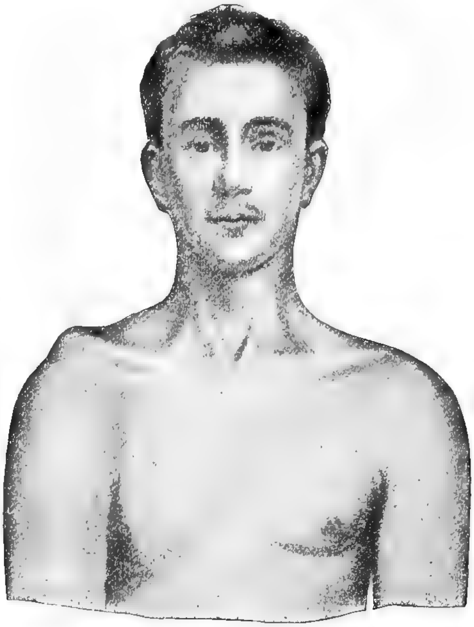

FIG. 1609.—Upward Dislocation of Acromial End of the Clavicle. (Helferich.)

of the clavicle; simple bandages passed over the shoulder and under the elbow; immovable plaster or other dressings; pads, straps, etc., in varying combinations; the ordinary Petit's tourniquet (well padded) placed over the end of the clavicle with the strap passing under the elbow; and Mayor's apparatus. All these have been tried, each one giving good results in some cases and failing in others. Sayre's dressing for fractured clavicle is about the simplest and most reliable. Many surgeons, however, advocate warmly Stimson's method of treating this dislocation. This is accomplished by means of a long strip of adhesive plaster, three inches wide, the middle point of which is placed over the front of the flexed elbow, and the ends carried up in front of and, behind the arm, crossing over the distal end of the clavicle and then being fixed to the front and back of the chest, while the bone is held in place by pressure over the elbow and clavicle. The forearm is supported by a sling and the arm is bound to the chest. The readiness with which an inspection can be made from time to time, so that a recurrence of the dislocation may be quickly detected, is a good feature of this method. On the other hand, the possibility of sloughing at any time at the point of the elbow must be watched for and prevented. Gross first suggested wiring with strong silver wire, and this was tried by Cooper, of San Francisco, and by Dr. Hodgen, of St. Louis, in two cases. Although in these two cases the procedure proved successful, Hodgen said that he would not repeat the operation except in cases of *very great* displacement.* Mayor's apparatus consists of a sling or casing for the forearm, with straps and buckles attached to the covering over the point of the elbow posteriorly; one of the straps passing over a compress placed over the distal end of the clavicle and attached to the casing in front of the elbow, the other passing over the sound shoulder and attached to the casing midway between the elbow and wrist.

Dislocation of the acromial end downward is exceedingly rare, only five cases having been cited by Hamilton; while Stimson † gives a total of twelve. So far as known, this dislocation is produced by direct violence, forcing the end of the clavicle downward. At the same time the lower angle of the scapula moves slightly outward, and the coracoid process is depressed,—thus saving it from being snapped off. The acromio-clavicular, coraco-clavicular, and coraco-acromial ligaments are ruptured, and the head of the clavicle rests on the capsule of the shoulder joint and beneath the acromion. The alterations and symptoms produced are the following: There is a marked depression at the point of dislocation; the acromion is usually prominent, and a groove or gutter may be felt along its inner border; the displaced clavicle can be detected beneath the acromion; while the arm may be moved by the surgeon pretty freely backward or forward, the patient is unable to lift the arm voluntarily; and, finally, there is more or less sharp pain, increased on movement of the limb.

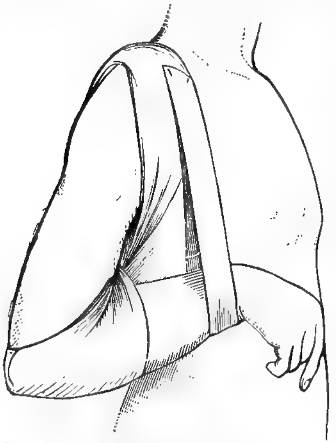

FIG. 1610.—Figure-of-8 Bandage from the Elbow. Side View.

The reduction is readily accomplished by drawing the shoulders outward and backward; the position being maintained by securing the base and lower angle of the scapula snugly and firmly to the body by a broad bandage and compress, while a sling is employed for supporting the arm in the desired position. These dressings are to be worn for six or seven weeks. The coracoid process prevents the bone from slipping out of its place as long as the scapula is maintained in the position suggested.

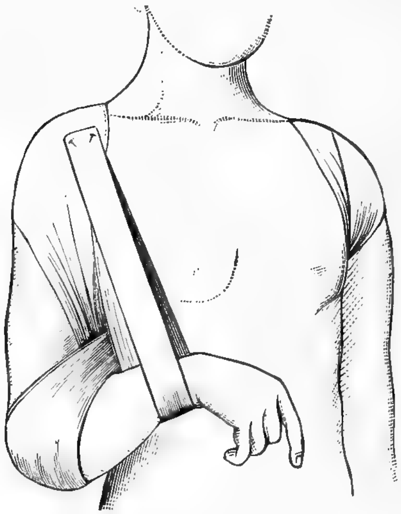

FIG. 1611.—Figure-of-8 Bandage from the Elbow. Front View.

Subcoracoid dislocation is yet more rare than any of the other varieties; the single case reported by Pinjon, and the five cases by Godemer of Mayenne, being all that so far have been cited. Hamilton is sceptical as to the existence of this form of dislocation. I quote the following from Wharton and Curtis:* "It is said to result from the shoulder being forced upward, outward, and backward, while at the same time the acromial end of the clavicle is driven downward. The most marked symptoms are: unusual prominence of the acromion and coracoid processes, pain and restricted motion of the arm, and an increase of the distance between the sternum and the summit of the shoulder. Treatment: To reduce this displacement the arm should be flexed and brought to the side and carried forcibly upward, inward, and backward, to relax the clavicular portion of the pectoralis major muscle. The clavicle should be grasped and disengaged from its position below the coracoid process and pressed back into its proper position. After reduction a Velpeau's bandage should be applied and the dressing retained for six or eight weeks."

Dislocation of the inferior angle of the scapula, though somewhat rare, may occur. The latissimus dorsi, or a portion of it, may slip beneath the lower end of the bone, —an accident which generally occurs in children as a result of lifting them by one arm. The effects produced are: Pain and difficulty in moving the arm, and a marked projection of the lower end of the bone, which is increased if the arm is drawn forward. Reduction, under these conditions, may be impossible.

Dr. E. M. Moore, in his article in the former edition of this work, places great confidence in his method of dressing a dislocated clavicle, and bases this confidence on the results obtained in sixteen cases which occurred partly in his own practice and partly in that of his friends, two of these cases being luxations at the sternal end. I quote from his article as follows: "The simple bandage which is here illustrated subserves the purpose with great assurance of success. This, as will be shown by the cuts, consists of the application of a shawl, or, what is better, a piece of common cotton cloth, about two and one-fourth yards in length, and a yard or so in width, folded like a cravat until it is about eight inches in breadth at the centre. The application of this bandage is conducted in the following manner: Place the bandage, thus prepared, upon the palm of the outstretched hand, with the finger and thumb in the line of its length and at its centre. This enables the surgeon, while placing it under the elbow of the patient on the affected side, to grasp it firmly, and so to adjust it that the border reaches about two inches up on the humerus, and about six inches down on the forearm. The grasp of the surgeon's hand retains the bandage in position during the succeeding manipulations. The first movement is to place the inner tail up over the shoulder, smoothing it out over its rounded surface, and then committing it to an assistant. The outer tail is now carried over the forearm, up behind the back to the top of the opposite shoulder. Traction is now made upon this tail so as to draw the elbow backward and toward the thorax, after which its end is brought over the shoulder and under the axilla of the unaffected side. The other tail is now seized, and when made tense it draws the shoulder backward. This is carried under the armpit, and over the point of the unaffected shoulder. The two ends are now secured by pins at the points where they overlap the bandage. This, as will be observed, produces the peculiar form upon the unaffected side known as the figure-of-8 bandage. The special twist around the elbow of the affected side is similar in form, although one end runs up over the shoulder. For these reasons the writer has called the bandage "the figure-of-8 from the elbow." The bandage, however, is not complete without a sling to hold the forearm slightly above the horizontal position while the patient is erect. If the forearm droops, the bandage becomes disengaged from the elbow, and the arm has a tendency to swing forward. But if it be placed in the position already indicated, its weight has a tendency to carry it backward. This sling is best constructed by placing a strip of cotton cloth, three or four inches wide, around the wrist, and pinning the two ends together upon the larger bandage as it passes over the shoulder. It is desirable, also, to fold the end that projects behind the elbow and secure it with a pin, so as to make a sort of cup which will hold the elbow in its place. This bandage is usually worn with great comfort to the patient, the points most complained of being the axillary border of the unaffected side and the extremities of the olecranon and condyles of the elbow held by the bandage.

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* *Op. cit.*, p. 681.

† "Treatise on Dislocations," by L. A. Stimson, M.D., LL.D., p. 191; Lea Brothers, publishers, 1888.

* *Op. cit.*, p. 564.

"Protection against this pressure can be afforded by little compresses, placed alongside the suffering points, and can be left entirely to the management of the patient. It is wise, however, to watch him daily for the period of a week, loosening the tails of the bandage and then tightening them a little. At the end of this time the capacity of stretching will have ceased." Dr. Moore further states that the dressing will have to be kept on for about two weeks, and he claims for it "better results than by any other method, as meeting more definitely and more practically the exigencies of this condition."

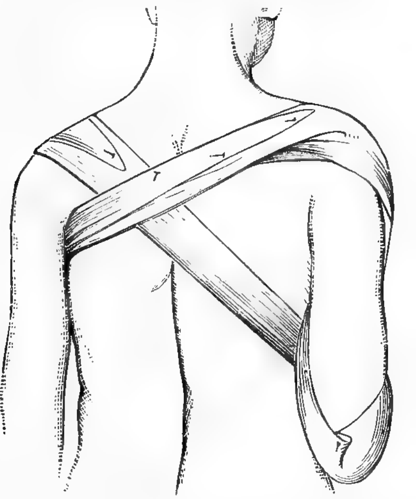

FIG. 1612.—Figure-of-8 Bandage from the Elbow. View from behind.

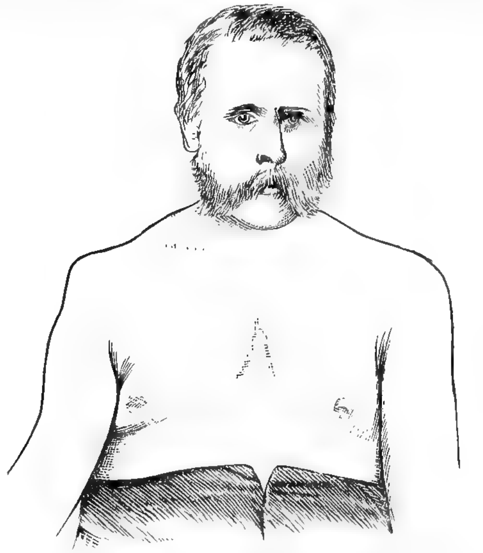

FIG. 1613. Subglenoid Dislocation. (Traced from a photograph taken twenty-three hours after the injury had been received.)

Dislocations of the Shoulder Joint comprise fully one-half of all dislocations; some observers even placing the proportion a little beyond this. On this account alone they constitute the most important class. Quite a number of varieties have been described, but the following table gives all that it is necessary to consider; others being but modifications of these, or secondarily assuming one of these forms, either accidentally or by manipulation.

Varieties of Dislocations of the Shoulder Joint.

1. Downward
   - Subglenoid (common).
   - Erecta (very rare).
2. Forward
   - Subcoracoid (common).
   - Subclavicular (rare).
3. Backward
   - Subspinous (rare).
   - Subacromial (rare).
4. Upward.—Supraglenoid (rare).

In the subglenoid dislocation we find the capsular ligament extensively torn on its under surface, permitting the head of the humerus to leave the glenoid cavity and take a position on the anterior edge of the scapula immediately below the glenoid cavity. The tendon of the long head of the biceps may be ruptured or completely detached from its insertion; the supraspinatus is stretched or lacerated; the infraspinatus, coraco-brachialis, and subscapularis are put upon the stretch, the latter sometimes torn from its attachment to the head of the humerus; the deltoid is placed in a condition of extreme tension, and paralysis of this muscle may be among the unpleasant sequelæ. The artery and vein may be injured, and the circumflex and other nerves may be seriously impaired.

Among the more frequent causes the following may be cited, in the order of their frequency: (*a*) a force applied to the upper end and outer surface of the humerus; (*b*) a fall upon the extended hand; (*c*) a fall upon the elbow. Sudden contraction of the muscles while the arm is strongly abducted may produce this luxation. It is perhaps one of the most frequent dislocations produced spontaneously, abduction of the arm favoring its production.

Among the most prominent conditions and symptoms that result from this dislocation may be mentioned the following: the presence of a depression under the end of the acromion; the elbow is carried out from the body a distance of three or four inches and a little backward; it cannot be made to touch the lateral surface of the body; the line of the axis of the limb is directed to the axilla, and decidedly below the glenoid fossa, which will be found empty; the head of the humerus can usually be felt in the axilla, especially when the limb is carried away from the body—Dugas' sign; inability to touch the opposite shoulder on top with the palm of the hand while keeping the elbow in contact with the chest; the outer surface of the arm presents two planes which are inclined toward each other and which meet at the insertion of the deltoid muscle; numbness of the arm and generally pain, especially when the attempt is made to bring the elbow to the side; possibly free passive motion, yet the elbow cannot be brought into contact with the side without great pain, which is doubtless due to pressure of the humerus on the axillary plexus. The existence of these symptoms, or of a majority of them, immediately after luxation, or after inflammation has subsided, should make it possible to arrive at a correct diagnosis; yet this may be rendered a difficult matter by the presence of a slight degree of crepitus—due to conditions which were mentioned in the earlier part of this article,—by the existence, during the intermediary period, of a large amount of inflammatory exudation, and finally by the presence, in fleshy persons, of a good deal of adipose tissue in the region of the shoulder. And here let me add that a failure to make a diagnosis is not due, in all cases, to want of a reasonable degree of skill, nor to a lack of painstaking efforts to ascertain the true condition of the parts.

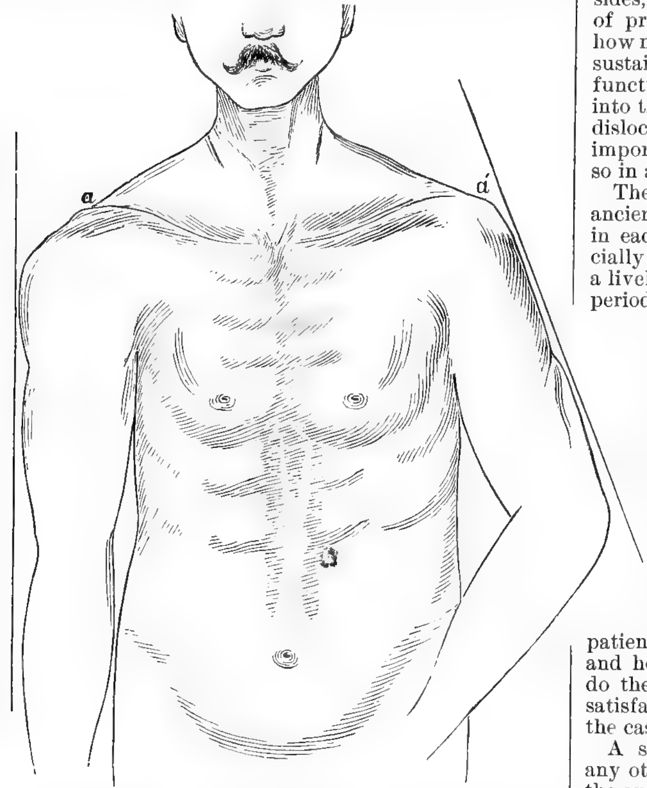

FIG. 1614.—Subglenoid Dislocation of the Humerus, Showing Flatness Beneath the Acromion. *a*, *a′*, Tips of acromion processes. The ruled lines indicate the test for dislocation by means of a straight-edge line on the arm.

Ordinarily, if the force producing the luxation has not been extreme, and reduction has been accomplished at a reasonably early period without a resort to excessive force or violence, which should ever be guarded against, complete recovery may confidently be expected in a comparatively short period of time. Yet the character of the injury producing the dislocation, and the absence of swelling, or the presence of only a slight degree of swelling, are not always indicative of the amount of damage sustained by important tissues in the immediate vicinity of this joint. The extensiveness of the swelling may be the result of grave injury to important blood-vessels, or, on the other hand, it may be due to the fact that the individual is predisposed to serous, fibrinous, or hemorrhagic effusion. In the case of a slight injury to the main trunk of the nerves or to some terminal branch, the pain may not only be great but it may appear at an early stage, and we may have in addition temporary loss of muscle functions. On the other hand, more serious nerve lesions may manifest themselves at quite a late stage, and, besides, they may be slow in attaining any marked degree of prominence. It is extremely difficult to say exactly how much injury muscles, nerves, tendons, or vessels have sustained, or to predict to what extent restoration of function may take place. I have gone somewhat fully into these points as affecting this particular variety of dislocation of the shoulder, yet they play a more or less important part in all forms of dislocation, and especially so in all the forms of dislocation of this important joint.

The time at which dislocations of the shoulder become ancient, or even irreducible, will vary to a great extent in each particular case. In a young person, and especially in one who is dependent on the use of the limb for a livelihood, six months might not be at all too long a period in which efforts more or less strenuous, though guarded and cautious in the extreme, could be justly essayed for reduction. On the other hand, in an elderly individual, or one whose circumstances did not imperatively demand thorough use of the limb, so great a degree of risk would not be justifiable. The time when these dislocations, or in fact any dislocations, become ancient, or even irreducible, is not to be measured in days, weeks, or months; each particular case, and each and every phase and characteristic bearing thereon, must be carefully weighed and thoroughly considered under a rigid observance of the rules of good common sense and judgment.

Although it is most important to inspire the patient with the greatest possible degree of confidence and hope, yet it is best to promise nothing more than to do the best you possibly can; and if this is not entirely satisfactory, it will as a rule be far better to surrender the case or to demand additional advice and counsel.

A shoulder-joint once dislocated is more liable than any other joint to undergo luxation a second time under the application of a different force or of one of the same character but of lighter degree; and that too even if the original reduction had been performed in the most perfect and satisfactory manner possible. This liability to a fresh luxation increases with the age of the patient.

In the case of a very muscular person who has dislocated his shoulder-joint, it is best, as a rule, not to attempt reduction until after an anæsthetic has been administered. But if the patient is seen immediately after the injury, and especially if sensation and muscular contraction are to some extent held in abeyance by the effects of primary shock, an anæsthetic may be dispensed with. Occasionally it will only be necessary to elevate the arm to an acute angle, or to a right angle to the body, when, the resistance of the deltoid and supraspinatus muscles being overcome, the bone returns to its place. At other times, slight extension and counter-extension, at the hands of the surgeon alone, in connection with manipulation, will suffice.

The late Prof. Moses Gunn, M.D., of Chicago, in a paper read before the American Surgical Association in 1884, regarded the upper and untorn portion of the capsule to be the chief obstacle in the way of reduction and he suggested the following: "The patient sitting on the floor, the arm is carried to an angle of 45°, and entrusted to an assistant, the surgeon placing his hands on shoulder with the tips of the fingers resting on the head of the humerus in the axilla. The assistant making upward and outward traction, the head glides into place guided and followed by the fingers of the surgeon; and the arm is lowered to the side, tension being kept up during this movement."

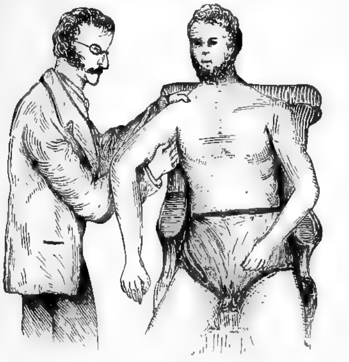
FIG. 1615.—Direct Reposition of Dislocated Humerus.

Sir Astley Cooper's method of placing the heel (divested of boot or shoe) in the axilla, where it acts partly as a wedge, forcing the head of the bone from the edge of the scapula, and partly as a fulcrum as well as a counter-extending force, will in many instances prove effective. In this procedure the forearm of the patient is to be flexed at a right angle with the arm, and both traction and a slight rotary movement are to be exerted upon the limb by the surgeon, who must be seated by the side of the recumbent patient. Sir Astley Cooper also in some cases substituted the knee for the heel in the axilla. With the patient seated in a low chair, the surgeon, having placed his foot in the chair beside the patient, brings the axilla over the knee; then, steadying the acromion and scapula with one hand, he presses the lower end of the humerus downward with the other.

In Prof. Nathan R. Smith's method counter-extension is made from the wrist of the opposite side; the patient being seated in a chair, while the surgeon, with his foot on the chair and knee in the patient's axilla, employs manipulation and extension by means of the injured arm, the extension being aided by traction on the wrist on this side (the affected side) by an assistant.

La Mothe's method consists in pulling the arm directly upward, while at the same time pressure is made downward over the shoulder-joint. According to Hamilton* Jobert succeeded, by means of this method, after twenty-three days, "when all the usual methods had failed."

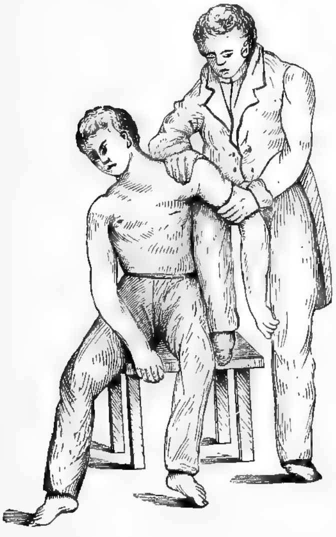
FIG. 1616.—Reduction of Dislocated Humerus, with Knee in Axilla. (Cooper's method.)

Skey's method is by the application of a padded knob of iron in the axilla, with two strong, straight branches extending laterally, and terminating in a bulb or ring by means of which counter-extension may be maintained. Extension is effected by compound pulleys.

I regard Kocher's method as the best, not only for this dislocation, but also for the subcoracoid variety, whch occurs next in frequency. He flexes the forearm upon the arm; carries the elbow against the side of the body; abducts the hand, in order to rotate the head of the humerus outward until resistance is experienced; then he carries the elbow forward, upward, and slightly inward, while the arm is still flexed at a right angle and the hand maintained in a position of forced abduction; and finally he rotates the arm inward and carries the hand up on to the sound shoulder. All of these movements are to be executed slowly and as gently as possible. According to this method, while the elbow is flexed at a right angle and pressed closely to the side of the chest, the forearm is turned as far as possible away from the chest, thus causing the arm to rotate externally. If, during the movement just described, the head of the humerus does not roll outward and in front of and below the acromion, the attempted reduction will fail. While external rotation is being accomplished the elbow should be carried well forward and upward, the arm next rotated inward, and finally the elbow lowered. During the latter part of these manipulations an assistant may render good service by pressing the head of the bone outward with his fingers or by pulling it outward by means of a hand introduced in the axilla.

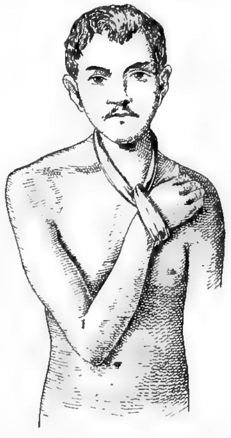
FIG. 1617.—Simple Apparatus for Keeping the Arms at Rest After Reduction of a Dislocation of the Humerus. (Helferich.)

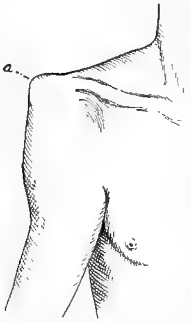

FIG. 1618.—Typical Subcoracoid Dislocation of the Humerus. (Helferich.)

The after-treatment of this, as of the other dislocations of the shoulder, consists in bandaging the arm closely to the side of the body for about ten days or two weeks, while the arm itself is to be carried in a sling. At the end of this time passive motion may be commenced, and the patient may be allowed gradually to resume the use of the arm, which must still be carried in a sling for a week or two longer. Violent movements must carefully be guarded against.

Dislocatio erecta is among the rare dislocations at the shoulder. In this condition we have the arm held vertically with the hand on top of the head, in order to avoid the intense pain which arises when it is held in any other position. The mechanism of this dislocation seems to be this: while the arm is extended forcibly and is also elevated, a blow descending on or near the proximal end of the humerus drives the head of the bone downward. It is usually readily reduced by making firm traction upward, with manipulation on the head of the humerus, and then bringing the arm down to the side as the bone glides into position. This variety of dislocation occurred in a case which came under my observation. A boy, falling from a tree, with his right hand extended, caught hold of a lower branch and

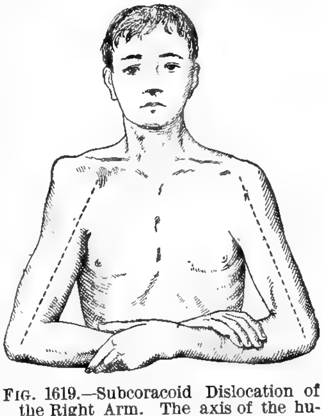
FIG. 1619.—Subcoracoid Dislocation of the Right Arm. The axis of the humerus is shown on both sides by the black lines. (Helferich.)

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* *Op. cit.*, p. 702.

thus to some extent broke the force of the fall; but by this act he threw the head of the bone down below the glenoid cavity.

In subcoracoid dislocation, which is mentioned in the recent work of Wharton and Curtis* as the most frequent variety, the capsular ligament is lacerated anteriorly and the head of the bone slips forward on the inner surface of the neck of the scapula. It is produced most frequently by direct violence acting on the posterior surface of the shoulder, although falling on the elbow or hand, with the arm extended and directed slightly backward, has occasionally been the cause of the dislocation. In some instances it has been attributed to muscular action alone.

Subclavicular dislocation is closely allied to the above variety. In it the head of the bone passes beyond the coracoid process and lodges just beneath the edge of the clavicle, being covered by the pectoralis major and minor muscles. If the force applied produces a fracture of the coracoid process this form of dislocation is most certain to occur. It produces more severe pressure on the axillary vessels and nerves than does the other variety. In either of the above dislocations the head of the bone can usually be readily made out in the abnormal position. In subclavicular dislocation there will be a marked depression under the outer edge of the acromion, extending beneath its posterior margin. The elbow hangs away from the body, a little backward, and the axis of the limb is directed toward some portion of the clavicle rather than toward the glenoid cavity. The supraspinatus and infraspinatus muscles and that portion of the deltoid which arises from the acromion are greatly stretched, if not torn. The measures required for reducing this dislocation are similar to those resorted to in subglenoid dislocations. Less extension, however, will be required and greater attention will have to be paid to manipulation of the head of the bone, which needs to be pushed more in a backward direction. Kocher's method will give by far the most uniformly gratifying results.

Backward dislocations are quite rare. The head of the bone may lodge just beneath the acromion or be carried farther back upon the dorsum of the scapula and beneath the spinous process. These dislocations are produced most generally by a force acting directly on the anterior surface of the shoulder. In the first of the two forms named above, the head of the bone will be observed beneath the acromion, and in both there will be a space more or less wide between the head of the bone and the coracoid process, into which space the fingers can be pushed more or less deeply. The axis of the bone is directed upward and backward, in a direction posterior to the glenoid cavity, and the arm comes across the front of the chest with the humerus rotated inward, unless the subscapularis is ruptured. The patient may hold the hand to the head, with the arm lying horizontally across the body, and it may be carried vertically. If the subscapularis is not torn the humerus cannot be rotated outward.

For the reduction of this dislocation the following plans have been suggested:—Slight forward traction (Duplay); direct pressure on the head of the bone, with slight extension (Mollière); traction at a right angle with the body, with moderate rotation (Desprès); raising the hand and arm and turning the hand backward behind the head (Sir Astley Cooper); moderate traction downward and outward, with pressure directly on the head of the bone (Hamilton); and, finally, traction outward, downward, and slightly forward (Parker), the shoulder being fixed by the hands of an assistant or by other means. The plan of Dr. Moses Gunn, of Chicago, was to have the shoulder properly fixed by an assistant, while the surgeon, taking the arm by the elbow and forearm, raises it to a horizontal position, carries it to the front, rotates it inwardly, and draws it into place.

Without fracture of the acromion or coracoid process, upward dislocation of the humerus seems wellnigh impossible, yet it has occurred in very rare instances. The symptoms consist in the absence of the humerus from the glenoid cavity and its being found in the interspace between the coracoid and acromion processes, in front of and above the level of the clavicle. In Albert's case, cited by Stimson,* both shoulders were dislocated. The patient, a full-grown man, while holding on to the reins of a pair of runaway horses, was dragged at full length on the ground. The deformity, which consisted of a prominence on the front and upper part of the shoulder, was more conspicuous on the left side than on the right. Stimson gives the following points in the symptomatology of this form of dislocation: "The limb hangs by the side, perhaps slightly abducted, and rotated outward; its axis is directed from below upward and forward, passing in front of the normal position of the head." "Voluntary movements," he says farther on, "are almost or quite impossible, and passive movements are greatly restricted, in old as well as recent cases."

The following methods of reduction have been suggested: Traction downward, under anæsthesia, combined with a tilting motion which brings the head of the bone back toward the glenoid cavity (Verneuil); carrying the arm away from the body until the head passes under the coracoid process, and then at the same time raising the elbow and rotating the humerus inward (Panas); abduction, extension backward, and rotation inward (Albert).

According to some observers there have been cases of partial dislocation of the shoulder in which, after rupture of the long head of the biceps, the contraction of the supraspinatus muscle has drawn the head of the bone almost, but not entirely, out of its normal position. Such a partial dislocation is marked by the presence of a depression on the posterior aspect of the joint, beneath the acromion, and by the existence of an unnatural rounded prominence formed by the head of the bone in contact with the coracoid process. Hamilton,† and Gerster,‡ however, entertain strong doubts in regard to the occurrence of such a partial dislocation.

Dislocation of the shoulder complicated with fracture is not unfrequently met with; the break usually occurring at the surgical neck. As preternatural mobility, crepitus, etc., accompany the signs occasioned by the presence of the head of the bone in its abnormal site, the diagnosis is not difficult. When the fracture occurs at the anatomical neck it is not always possible to make the diagnosis certain unless a very careful and thorough investigation is made. If the head of the bone cannot be restored to the glenoid cavity by reasonable manipulation of this fragment alone—the arm affording no assistance—it will probably be best to wait four or five weeks until union has taken place, and then to make efforts at reduction. It must be remembered, however, that under these circumstances there is very great danger of refracturing the bone, and consequently proper precautions, such as firmly but temporarily applying splints, bandages, etc., must not be neglected. McBurney§ effected reduction in one case by cutting down through the deltoid upon the lower end of the fragment, drilling a hole into it, and inserting into this hole a right-angled hook, by means of which he made forcible traction and rotation of the fragment. The propriety of removing the head of the bone will in some instances require consideration, and the operation may be necessitated in irreducible cases, if great suffering and inconvenience exist.

Dislocations of the Radius may occur forward, backward, or outward. In all cases the lateral and annular ligaments are torn and the head of the bone will be found in front of, behind, or external to, the external condyle of the humerus.

Forward dislocation is the most common variety and is generally produced by falling upon the hand while it is in a state of pronation, though direct force applied to the side of the elbow may produce it. The symptoms and alterations are: The radial side of the forearm is shortened and inclined outward; a depression will be found below the external condyle of the humerus; during movements of pronation and supination the head of the radius can be felt rotating in front of the elbow; and flexion as well as complete extension is prevented.

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* *Op. cit.*, p. 565.

* *Op. cit.*, p. 249. † *Op. cit.*, p. 739.
‡ N. Y. Med. Journ., May, 1878, p. 487.
§ "American Text-Book of Surgery," 3d edition, 1899, p. 442, W. B. Saunders & Co., publishers, Philadelphia.

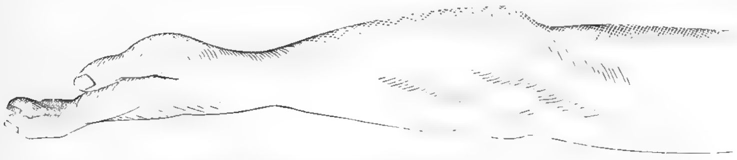
FIG. 1620.—Forward Dislocation of the Head of the Radius; Forearm Supinated and Extended.

To effect a reduction, the surgeon must flex the patient's arm upon the forearm with one hand, and with the fingers of the other he must make pressure upon the head of the radius in a downward and outward direction, the hand of the injured arm being at the same time sharply pronated. A well-padded right-angled splint, with a compress over the head of the radius, should be worn for several weeks, and after the first week it should be taken off at intervals of two or three days and passive movements of the limb should be cautiously executed.

More rarely, the head of the radius passes through the posterior part of the capsular ligament, and rests behind the condyle of the humerus. This dislocation is caused by direct violence, or by falling upon the hand when it is in a state of extreme pronation. The head of the bone will be found behind the condyle of the humerus, with a depression below it, the forearm being slightly flexed and the hand pronated. Supination, under these conditions, is impossible, and flexion and extension are diminished.

With the aid of an assistant who is to make counter-extension, the surgeon should first extend and then supinate the flexed forearm, at the same time pressing the head of the bone forward. An obtuse-angled splint, well padded, should be worn on the forearm for several weeks. As was suggested in the paragraph relating to dislocations of the radius forward the splint should be removed from time to time and passive motion should be carried out.

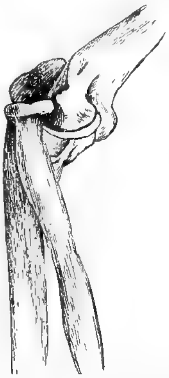
FIG. 1621. - Dislocation of the Ulna Backward, without the Radius.

Dislocation of the radius outward, in which the head of this bone rests on the epicondyloid ridge, is still more rare. The conditions which indicate the existence of this variety of dislocation are: prominence of the radial head above and in front of the external condyle of the humerus; the arm flexed and held in a position midway between pronation and supination; and impairment of flexion and extension.

For the reduction of this dislocation it is necessary that, while counter-extension is being made, the arm, moderately flexed, should be extended, and that, at the same time, pressure should be made on the head of the radius in a downward and forward direction. A right-angled splint should be worn as in the first variety.

The ulna may be dislocated directly backward, the radius being left *in situ*, and the coronoid process dropping into the olecranon fossa or resting on the posterior inner surface of the inner condyle. There will be some shortening of the forearm but not as much as in dislocation backward of both radius and ulna. The latter variety is doubtless one of the most frequent dislocations at the elbow; and as practically the same treatment is required for both of these forms, the subject will be considered in a single paragraph a short distance farther along.

The symptoms of dislocations of both bones of the forearm backward at the elbow are: shortening of the anterior surface of the forearm; the presence of a marked prominence in front of the elbow (due to the projection of the lower end of the humerus); and the presence of a still greater prominence posteriorly (produced by the olecranon and the tendon of the triceps). The arm is slightly flexed, the elbow rigid, and all movements are difficult. The condition is likely to be confounded with condyloid or supracondyloid fracture of the humerus. The relations of the olecranon with the condyles, in a dislocation at the elbow, are altered; in a fracture they are unchanged. In dislocation the prominence posteriorly is increased by flexion and diminished by extension, while the opposite holds good in fracture. In fracture the deformity disappears on firm extension and counter-extension, but reappears when it is removed; in dislocation, if we can remove the deformity by this means it does not return.

When the parts are completely relaxed reduction is easily accomplished by two opposite movements: Fix the arm, flex the forearm, and make traction at the same time; or fix the arm, extend the forearm, and, while making traction, suddenly flex the forearm. An anterior angular splint, well padded, should be worn for two or three weeks, and there should be occasional passive movements and massage. Sir Astley Cooper, in reducing a dislocation at the elbow, caused the patient to sit in a chair, and placing his knee on the inner side of the elbow-joint, in the bend of the arm, he took hold of his wrist and bent the arm; at the same time he pressed on the radius and ulna with the knee, so as to separate them from the humerus, the coronoid process being thus lifted out of the humeral fossa; and while the pressure was being kept up by the knee, the arm was forcibly but slowly bent, until the ends of the bones resumed their natural relations.

Dislocation of the ulna and radius forward, both bones lying in front of the condyles, is rare. The broad surface of the humerus can be felt posteriorly, and the olecranon and head of the radius in front. If the dislocation is complete, the forearm is apparently shortened and flexed upon the arm; if it is incomplete, the forearm will be extended upon the arm. It is reduced by extension alone, or, if this does not suffice, by extension and forced flexion.

Complete lateral dislocation of both bones is quite rare, and incomplete dislocations are possibly less so; they are produced by violence acting in opposite directions on the arm and forearm. The arm will be found flexed and inclined either inward or outward; the olecranon will project beyond the internal condyle in the one instance, and the head of the radius beyond the external condyle in the other. In dislocations outward the external condyle is quite prominent owing to the absence of the head of the radius. The hand will be pronated. In reducing such a dislocation, while extension and counter-extension are being carried out, the bones of the arm and forearm should be pushed in opposite directions.

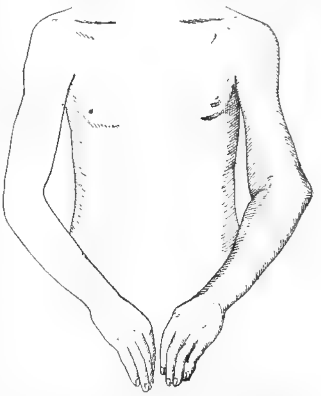
FIG. 1622.—Backward Dislocation of Both Bones of Left Forearm, Showing Prominence of Olecranon and Shortening of Forearm. (Helferich.)

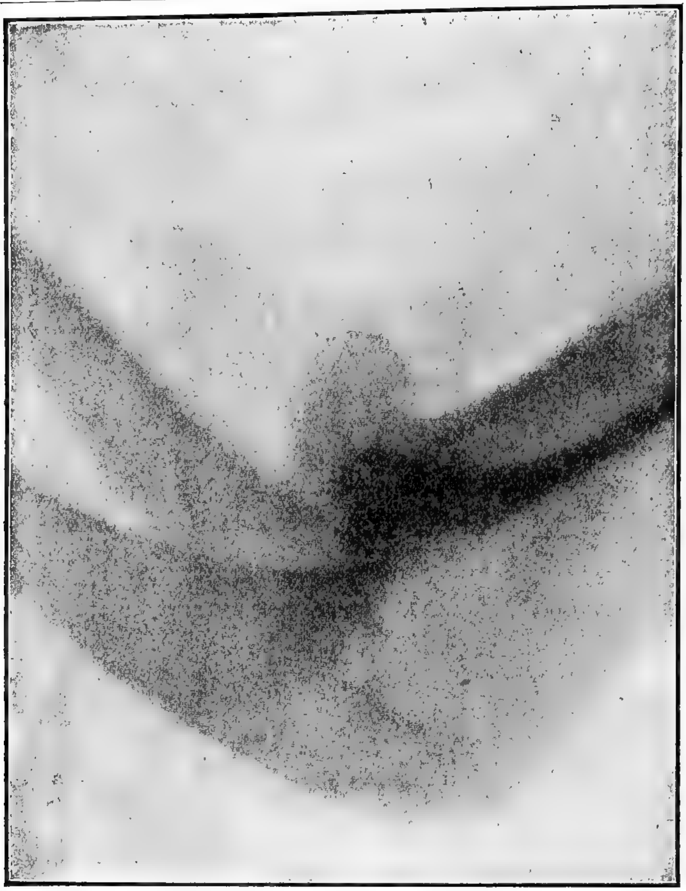

FIG. 1623.—Backward Dislocation of Both Bones of Forearm in a Child. (x-Ray picture, copied from David Walsh's work, Edinburgh, 1899.)

In compound dislocations at the elbow, the propriety of removing—under strict aseptic precautions—the offending fragments is to be considered. In such cases a partial resection offers better chances of success than does reduction with a reunion of the fragments.

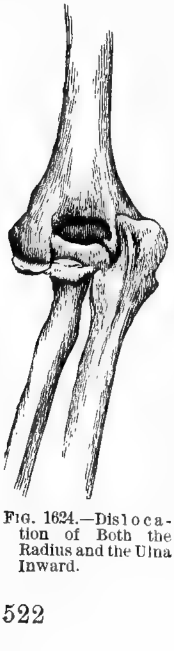

FIG. 1624.—Dislocation of Both the Radius and the Ulna Inward.

In Dislocations at the Wrist we may have the ulna detached from the semilunar surface of the radius and displaced forward or backward. If forward, it is the result of violent supination of the hand, and is accompanied by rupture of the anterior ligaments of the joint. Somewhat to the radial side and on the palmar surface of the wrist a prominence will be apparent, and that of the lower end of the ulna at the back of the wrist will be wanting; the hand will be supinated. With the forearm flexed, counter-extension should be made from the arm, and extension should be applied to the hand. At the same time pressure backward should be made over the head of the ulna, whereupon firm pronation will enable the ulna to slip back into position. Two well-padded splints, such as are used in fracture of both bones of the forearm, should be worn for at least four weeks.

Backward displacement of the ulna is the result of extreme pronation of the hand. The ordinary ulnar prominence at the back of the wrist will be found, in this dislocation, to be much more conspicuous, and the styloid process will no longer be in line with the fifth metacarpal bone; the hand will be supinated and the fingers flexed. When the hand is extended, the bone is pushed back until it becomes re-engaged in the semilunar cavity of the radius. The after-dressing consists in applying to the bone a firm compress and a straight posterior splint for a period of three or four weeks; and then, after these have been removed, the wrist should be strapped with rubber plaster, or a bandage and compress should be applied. These dressings should be worn for some time.

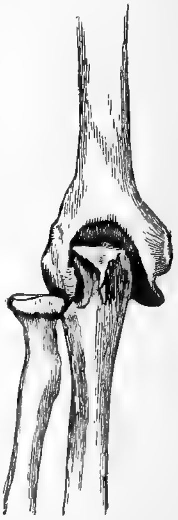

FIG. 1625.—Dislocation of Both the Radius and the Ulna Outward.

Dislocation of Both Bones at the Wrist may take place in either an anterior or a posterior direction. The lesion is quite rare. When the wrist is extended violently and to an extreme degree, the anterior carpal and lateral ligaments are ruptured and the bones of the carpus forced back on the anterior surface of the radius. The hand will be fixed in an extended position, the lower end of the radius and ulna forming a prominence on the posterior surface of the wrist. By making extension from the hand and counter-extension from the arm, and by extending the carpus on the forearm while at the same time pressing the ends of the radius and ulna forward, the luxation may be reduced. The hand and forearm should be placed on a well-padded anterior splint, and secured by a roller bandage. These dressings should be worn for several weeks.

The application of force to the back of the hand in such a manner as to produce extreme flexion may cause rupture of the posterior radio-carpal and lateral ligaments, and force the carpus back on the posterior surface of the radius and ulna. The deformity consists in marked increase in the antero-posterior diameter of the wrist, the hand being slightly extended, the fingers flexed, and the

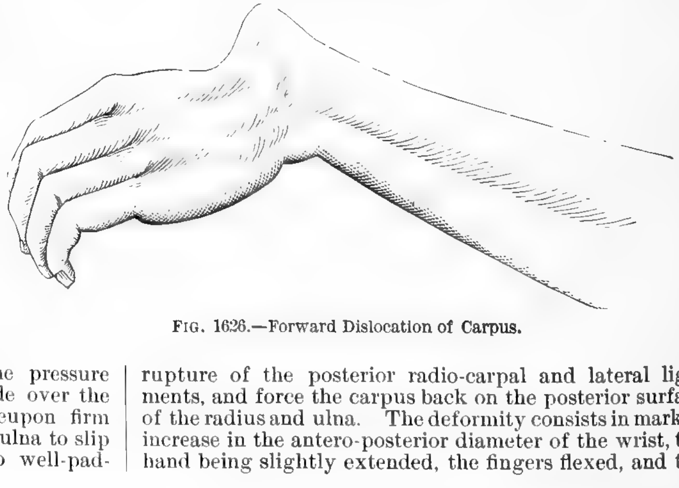

FIG. 1626.—Forward Dislocation of Carpus.

joint immobile. With the forearm fixed, extension from the hand combined with slight flexion, abduction, and adduction, will effect a reduction of the dislocation. A straight splint, applied to the anterior surface of the forearm and hand, should be worn for several weeks.

In discriminating between a fracture of the wrist and a dislocation at this point we are aided by the following facts: in a fracture there is increased mobility with crepitus, and the deformity reappears after it has been reduced, provided no dressings are applied to keep the parts in place.

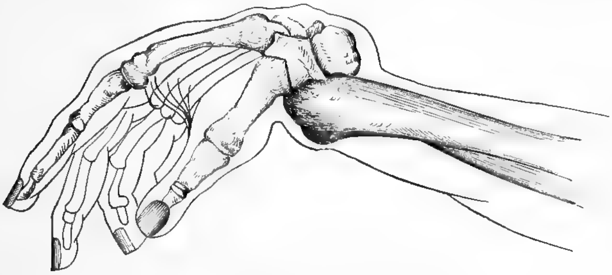

FIG. 1627.—Backward Dislocation of Carpus.

In compound dislocation at the wrist, the fragments of bone should be removed under rigid asepsis, all torn nerves, tendons, etc., should be sutured, bleeding vessels should be ligated, and a well-padded palmar splint should be applied.

Dislocations of the Carpal and Metacarpal Bones are rare, and no specific instructions are likely to meet the indications in any particular case. A knowledge of the anatomical relations, comparison with the uninjured hand, and general attention to practical surgical measures are the only things that are necessary. The displaced bones should be moulded into position with the fingers of the operator and properly secured in this position by a splint and bandage.

The metacarpal bone of the thumb may be dislocated backward or forward by extreme extension or flexion; the reduction is to be effected by making extension from the proximal phalanx and by pressing the displaced bone back into position. As a dressing a moulded binder's board or a leather or gutta-percha splint, should be fitted to the thumb; it should extend well back over the wrist, and should be secured by a narrow roller.

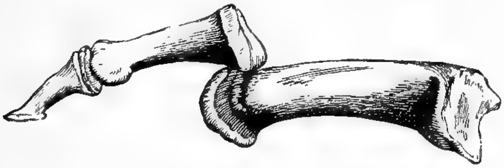

FIG. 1628.—Dislocation of Phalanx of the Thumb Backward.

The Thumb is dislocated most commonly by a backward or forward displacement of the proximal phalanx, the proximal end passing in front or back of the head of the metacarpus. As a rule, the backward dislocation is rendered more difficult of replacement by reason of the head of the bone being grasped between the two heads of the flexor pollicis brevis. In effecting a reduction the metacarpal bone should first be fixed, and then the thumb is to be extended, drawn downward, and suddenly flexed. If this fails, one of the heads of the short flexor may be divided subcutaneously. A dressing similar to the one just cited will be appropriate. Noty* suggests the following plan as having succeeded in backward dislocation of the thumb after other efforts have failed: "The hand flexed and forcibly pronated; the surgeon's two fore-fingers placed beneath the head of the metacarpus, and the thumbs applied to the dorsum of the phalanx at its base, pressure is made in opposite directions as the thumb is raised to a right angle."

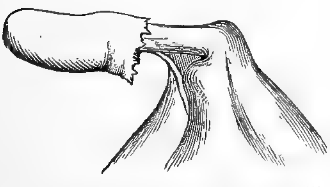

FIG. 1629.—Dislocation of Phalanx, without Rupture of the Flexor Brevis.

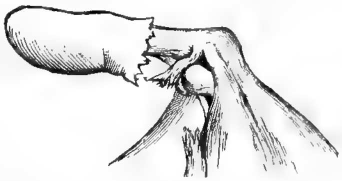

FIG. 1630.—Dislocation of Phalanx, with Rupture of Muscle: Head of Metacarpal Bone Covered Only by Skin.

Reduction of Dislocation of the Phalanges is not difficult, and is usually accomplished by firm extension and manipulation. In compound dislocations of the phalanges efforts to secure perfect asepsis are essential. If the bones are extensively comminuted, the removal of fragments, excision, etc., may be needed, and as in simple dislocations, a moulded binder's board, or a leather or gutta-percha splint, should be applied.

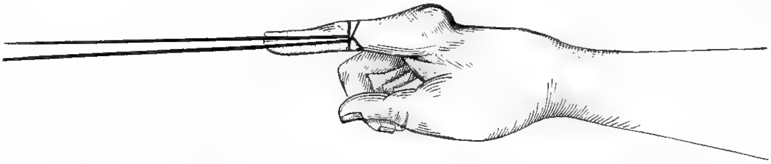

FIG. 1631.—Reduction of Backward Dislocation of First Phalanx with Clove-Hitch.

Dislocations of the Pelvic Bones partake more of the nature of a fracture, and for their diagnosis a careful study of the relations of the various prominences and of the degree of mobility at the point of separation, usually suffices. In order to secure a satisfactory examination the patient should be placed on a firm, well-padded table or mattress. The treatment consists in manipulating the bones into position and in applying broad strips of adhesive plaster and a well-adjusted muslin roller; or a plaster-of-Paris dressing may be applied, and this should be worn for a month or six weeks.

The displacements of the coccyx, whether from fracture or from dislocation, present similar indications; and if, after they have been reduced, a redisplacement occurs, giving rise to discomfort or inconvenience, removal of the bone is the proper recourse. Replacement is accomplished by means of the fingers of one hand placed in the rectum, while the other hand makes pressure from without.

Dislocations of the Hip, or Coxo-Femoral Dislocations, are liable to occur most frequently in four directions: (1) upward and backward on the dorsum ilii, (2) upward

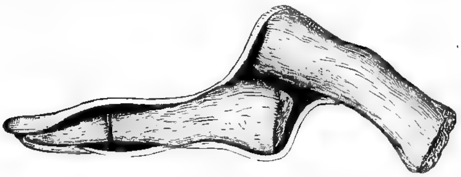

FIG. 1632.—Forward Dislocation of Second Phalanx of Finger.

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* British Medical Journal, October 15th, 1898.

and farther backward into the ischiatic notch, (3) downward and forward into the thyroid foramen, and (4) downward and forward upon the pubes. In addition, what are known as irregular dislocations are occasionally met with, as diagonally between any of the above, and in some rare instances going beyond the thyroid foramen and lodging upon the tuberosity of the ischium. Slight manipulation, however, readily brings the head of the bone into one or the other of the four positions known as regular dislocations. Irregular dislocations are found only in cases in which the ilio-femoral or " Y " ligament is completely ruptured. If this ligament remains intact the head of the bone should be forced to take its position in one of the regular forms.

"In regard to frequency," says Hamilton,* "of 104 dislocations (regular), 55 were upon the dorsum ilii, 28 into the great ischiatic notch, 13 upon the foramen thyroideum, and 8 upon the pubes." They may occur at any period of life, but are found most frequently in the most active period, viz., from 15 to 45; and in regard to this matter I will quote the following tabular arrangement from Hamilton. On page 810 I find:

Under 15 years	15 cases.
15 to 30 years	32 "
30 " 45 "	29 "
45 " 60 "	7 "
66 " 85 "	1 "

The above is his analysis of 84 cases.

The injury is more common in males than in females, Agnew giving 78 out of 89 cases, and Hamilton 104 out of 115. Continued fevers possibly predispose to dislocations of the hip, especially in the young. Double dislocations have been reported by numerous observers.

In dislocation upon the dorsum ilii, the limb is shortened from one and one-half to two and one-half or three inches, rotated inward, adducted, and slightly flexed upon the pelvis. During the examination the patient should stand erect, and should throw the weight of his body upon the sound foot, the knee touching the opposite thigh above or near the upper margin of the patella. The thigh can be flexed, but adduction is difficult, and abduction is impossible except to a very limited extent; the body is bent slightly forward; the roundness of the hip is diminished by relaxation of the gluteal muscles; the trochanter major is brought down so as to approach the level of the anterior superior spinous process; and the head of the bone may be felt on the dorsum ilii.

In differentiating this dislocation from fracture of the neck of the femur, we shall find absence of crepitus (unless fracture coexists), immobility, the toes turned in, a greater degree of shortening, and inability to stand upon the limb. In fracture, on the other hand, there is mobility —possibly preternatural; the toes are generally turned out; the shortening is limited if at all apparent; and the patient can bear some weight on the limb, and may even be able to walk a short distance. It must also be borne in mind that a fracture is more liable to occur in advanced life; indeed it is quite rare in early life or prior to middle age. Separation of the epiphysis must be looked out for in early life, and the possibility of hip-joint disease must not be forgotten.

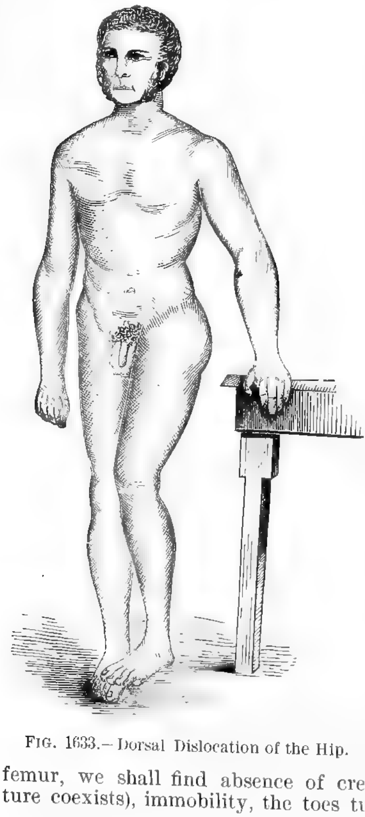

FIG. 1633.—Dorsal Dislocation of the Hip.

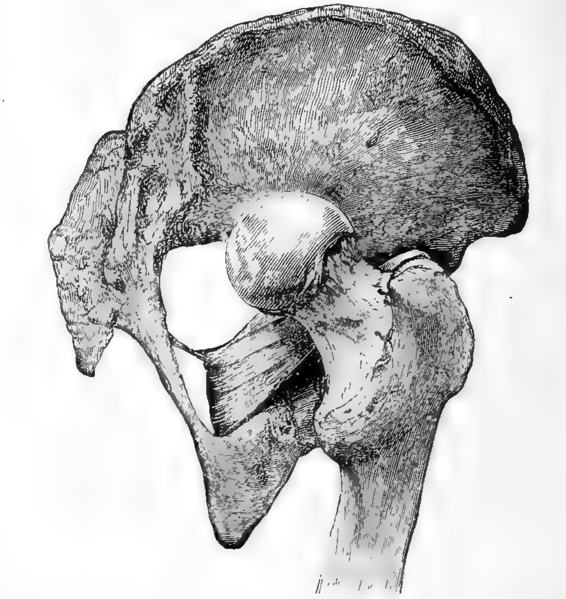

FIG. 1634.—Dislocation on Dorsum Ilii Below Tendon of Obturator Internus. (Bigelow.)

If the outer fibres of the ilio-femoral ligament are ruptured, the rare form of everted dorsal dislocation may occur, in which we have the principal signs of a dorsal dislocation with the limb everted; the limb may be found inverted, but it is easily everted; and the foot may be slightly everted, lying flat upon the bed, or it may point backward. By flexion, rotation inward, and adduction this dislocation is readily converted into the regular form on the dorsum ilii.

In this dislocation, as with the others, the ligamentum teres is ruptured or torn from its attachment; the capsular ligament is torn at its lower posterior portion, and generally also on its under part; the quadratus femoris, the gemelli, the obturator internus, the pyriformis and obturator externus muscles, all or at least some of them are torn or partially lacerated. The glutæi, on the other hand, either escape altogether or are only slightly injured.

The head of the bone may lie close to the acetabulum, even overlapping its cavity, or it may be lodged far backward, or backward and upward; it may be so low as to overlap both sciatic notches, its centre resting on the base of the ischiatic spine or opposite the apex of the great sciatic notch.

When the head of the bone leaves the acetabulum at its lower part it usually passes below the obturator internus and then rises behind it, this muscle being interposed between it and the cavity; or lodging beneath this muscle it may press it forcibly upward; or finally, it may slip above the obturator internus, passing between it and the pyriformis, in which case it will be covered only by the glutæus maximus and the integument. In the latter event, the head of the bone can be felt in its new position, moving with the movements of the thigh; the normal outline of the buttock, which becomes broadened and prominent, is lost, and the great trochanter is approximated to the anterior superior spine, lying above a line drawn from that point to the tuber ischii (Nélaton's line). If the head of the bone is below the tendon the symptoms will be practically the same, yet there is less shortening, and the flexion, adduction, and inversion are more marked.

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* *Op. cit.*, p. 808.

Reduction is accomplished, in all recent cases, by manipulation. The studies of Dr. Bigelow have thrown great light upon dislocations at the hip, and he very correctly gives priority of invention of the method now so commonly in use to the late Prof. Nathan Smith, of New Haven, who formulated it in 1831. Desprès,* in 1835, independently formulated the method of flexion and outward rotation, and Reid,† in 1851, did the same. In his method, however, marked adduction preceded the flexion, and the obstacles encountered were incorrectly attributed by him to the resistance of the muscles.

In reducing this dislocation by the classical method of Professor Smith, the patient is placed on a firm mattress and anæsthetized (if deemed necessary); the surgeon grasps the ankle of the injured limb with one hand and the knee with the other; the leg is flexed on the thigh and the thigh on the abdomen; it is then adducted and carried to the sound side, and rotated slightly outward; and finally, by circumducting externally, it is swept across the abdomen and brought down in a straight position beside the other limb.

Allis‡ recommends the following steps: The surgeon, kneeling beside the recumbent patient, in the case of the right hip, should grasp the ankle with the right hand and place the bent elbow of the left arm in the popliteal space; then he should turn the leg outward, by means of the ankle, and should lift it upward with the left arm; finally, he should turn the leg inward and should bring the femur down into the position of extension.

Hamilton§ gives the following: "The patient being laid upon his back upon a mattress, the surgeon, assuming that it is a dislocation upon the dorsum ilii, should seize the foot with one hand, and the other he should place under the knee; then flexing the leg upon the thigh, the knee is to be lifted carefully toward the face of the patient until it meets with some resistance; it must then be moved outward and slightly rotated in the same direction until resistance again is encountered, when it must be gradually brought downward again to the bed."

I also quote the following from Stonham‖: "In all forms of dislocations the patient is most conveniently placed upon a hard mattress on the floor, the surgeon thus having full command of the limb. He must be fully anæsthetized. In the dorsal dislocations the surgeon, flexing the knee to a right angle, grasps the leg above the ankle, and just below the knee. The thigh is now flexed upon the abdomen to a right angle, and the patient is slightly raised from the mattress so that his body becomes a counter-extending force; if this be insufficient his pelvis may be fixed by an assistant, or the surgeon may exert pressure on the anterior superior iliac spine with his unbooted foot. The femur is now abducted and rotated out, and thus the head is brought nearer the acetabulum; finally the limb is extended and the head slips into the socket. The formula for reduction is 'lift up, bend up, roll out, and extend.' If any difficulty is experienced it will most likely be due, not only in the dorsal, but in all regular dislocations, to the smallness of the aperture in the capsule; this is to be made larger, without fear of inflicting much additional damage, by circumduction in the direction opposite to that which the head of the bone must subsequently travel. In the other cases adduction and inversion may be slightly increased in order to disengage the head of the bone."

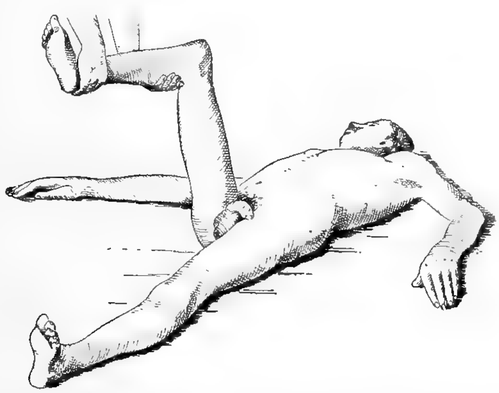

FIG. 1635.—Manipulation Method for Reduction of Dislocation of the Thigh, First Stage, Showing Flexion of Knee and Hip to a Right Angle. (Helferich.)

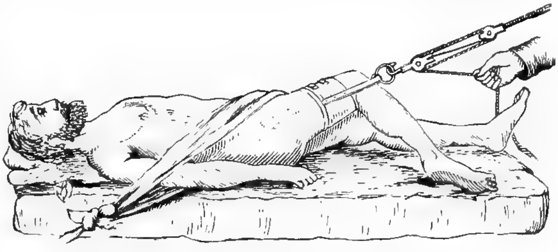

FIG. 1636. Extension. Sir Astley Cooper's Method.

"In the everted dorsal dislocation it may be converted into the ordinary dorsal by flexion, adduction, and inward rotation of the limb," says Mr. Stonham; and according to him "Bigelow recommends that the head should be disengaged by circumduction of the extended limb inward, coupled with eversion to free it from the edge of the pelvis in the supraspinous form." "The anterior oblique may be converted into the ordinary dorsal form by inward circumduction and internal rotation."

Charles A. Sturrock* has advised the following method of reducing dislocations of the hip: "The patient is laid upon the back and anæsthetized. The surgeon kneels upon the left knee and at the left side of the patient in a dislocation of the left hip. The patient's thigh is then carefully flexed to a right angle, and while this is being done the leg is also flexed to a right angle and laid with the most prominent part of the calf on the right knee of the surgeon. The ankle is then firmly grasped with the left hand, and the condyles of the femur with the right. The thigh is abducted for thyroid dislocations, adducted for dorsal and pubic, and rotated inward for all, by drawing the foot away from the middle line and keeping the knee steady. Traction is now made by steadily depressing the ankle, the surgeon using his knee for a fulcrum; the patient's leg makes a most powerful lever, and the pelvis can be easily raised from the ground if necessary, the body acting as a counteraction; finally the thigh is rotated out, and while this is being done the head of the femur slips into place."

These methods all act in the manner suggested by Prof. Nathan Smith, and the points brought out in regard to the ilio-femoral or "Y" ligament, so philosophically considered by Dr. Bigelow, are the important factors in the pathology and reduction of this dislocation,—the "Y" ligament being a re-inforcement of the capsular ligament. The method of Allis and that of Sturrock give the surgeon greater power in making extension and counter-extension during the manipulation. Sir Astley Cooper's method of employing the compound pulleys, and other devices, mechanical in their character, for extension and counter-extension, are now abandoned as being very liable to produce injury (through the employment of excessive force) in all recent dislocations; and, with the means suggested above, they are needed only as adjuvants to manipulation, if at all. Manipulation is to some extent impeded by mechanical devices, for they interfere with the freedom of movement; I never resort to them unless I am absolutely forced to do so, through the failure of other means, and then I rely upon them only as aids to the proper movements of the limb. I am convinced that I can accomplish more—while at the same time incurring a smaller risk—by a careful study of the mechanism of the dislocation and by employing dexterity, than by resorting to violent force.

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* Bull. de la Soc. Anatomique, September, 1835, p. 4.
† Buffalo Med. Journal, 1851.
‡ Wharton and Curtis: "Practice of Surgery," *op. cit.*, p. 585.
§ *Op. cit.*, p. 835.
‖ "Manual of Surgery," by Charles Stonham, vol. ii., p. 195, The Macmillan Co., 1900.

* British Medical Journal, April 8th, 1899.

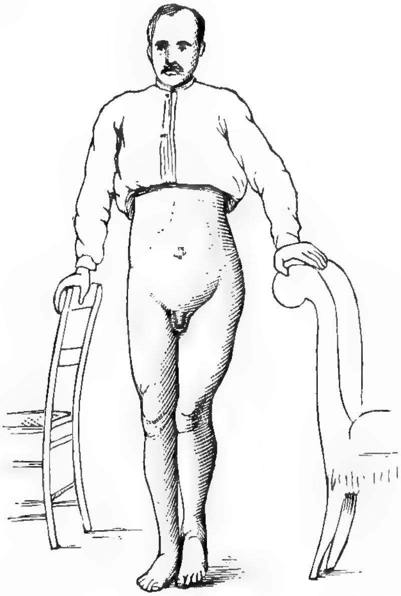
FIG. 1637.—Luxation in Ischiatic Notch. (From a Photograph.)

When reduction has been accomplished the limb may be kept in position by sand bags, or by the use of a long fixed splint, the patient being kept in bed for about two weeks; at the end of which time passive motion may be gradually essayed, and the patient allowed to get about on crutches, but he should not actually use the limb until after the expiration of a month. At the end of five or six weeks all support may be dispensed with.

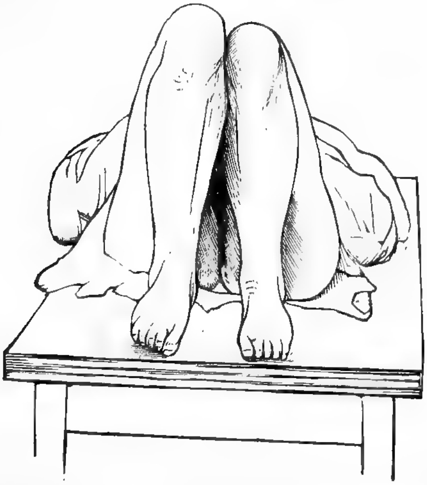
FIG. 1638.—Drawn from a Photograph. The same case as that shown in Fig. 1637.

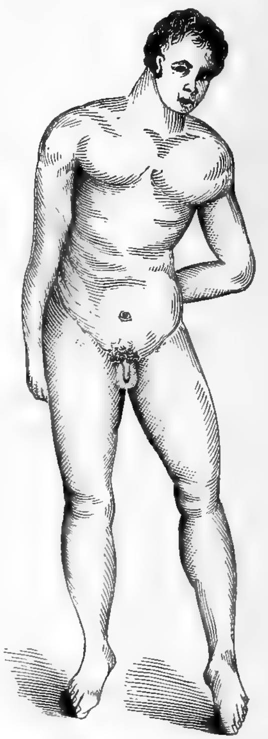
FIG. 1639.—Thyroid Dislocations.

As before stated, in connection with other dislocations, it is not time alone that determines when a dislocation at the hip-joint becomes ancient. However, if two months have elapsed, forcible attempts are likely to be dangerous and failure to effect a reduction is common, the danger becoming greater and the failure more certain with the advance of time. Nevertheless, attempts are justifiable and may prove successful and safe in one individual at the end of a certain period, while the obverse is the case in another individual, after the lapse of the same or even a shorter period of time.

Dislocation backward into the great sciatic notch is usually produced by a force acting on the knee, foot, or pelvis when the thigh is flexed on the pelvis. The limb is slightly flexed, inverted and adducted, with the knee turned toward and touching the inner margin of the patella of the other leg. The shortening is rarely more than half an inch, the hip is less prominent, the trochanter is farther from the anterior superior spinous process of the ilium, and the head of the femur is lower and less movable than when it rests on the dorsum ilii.

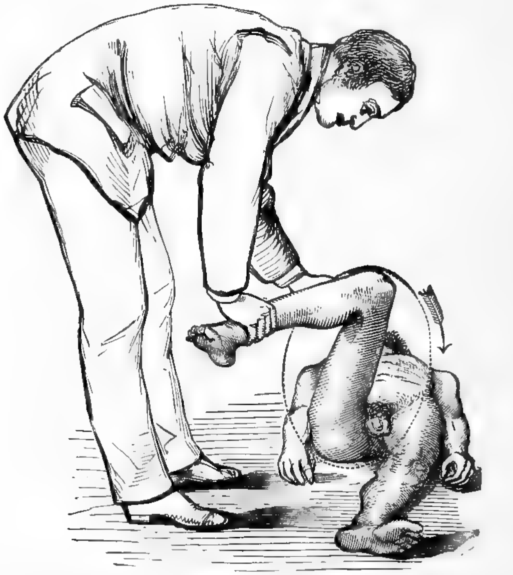
FIG. 1640.—Reduction of Thyroid Dislocation by Manipulation. (Bigelow.)

Flexing the thigh, in iliac dislocations, relaxes the "Y" ligament, and in ischiatic dislocations it releases the head of the femur from the obturator internus muscle. The surgeon, grasping the ankle in one hand and the front of the knee in the other, should flex the leg on the thigh, and the thigh on the abdomen; he should then adduct the limb and carry it over to the sound side, rotating it slightly outward; and finally, by a sweep of extreme circumduction, he should carry it across the abdomen and bring it down parallel with the other limb. Reduction by extension and counter-extension is now rarely resorted to, and only in old dislocations, and as an adjuvant to manipulation.

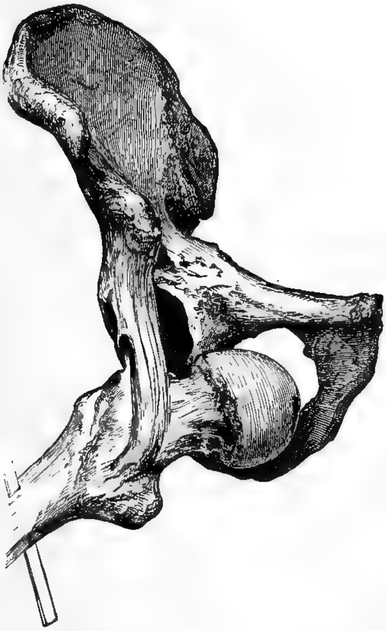

Fig. 1641.—Mechanism of Dislocation into Thyroid Foramen, Showing the Y-ligament Suspending the Trochanter. (Bigelow.)

A force acting upon the limb while in a state of abduction will throw the head of the bone downward, lodging it on the thyroid foramen and upon the obturator externus muscle. The limb will be lengthened about an inch and a half, the heel raised, the hip flattened, the body inclined forward on the pelvis and toward the injured side, and the foot may be everted. The head of the bone may be felt below the horizontal ramus of the pubis.

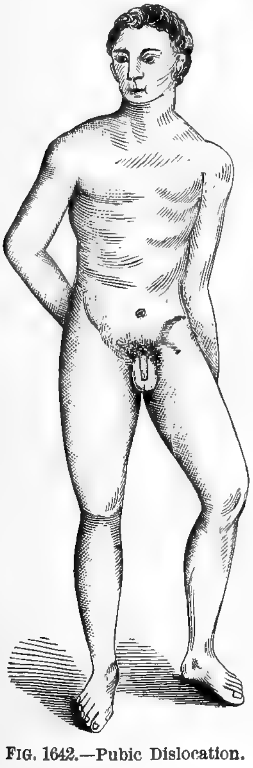

Fig. 1642.—Pubic Dislocation.

With the leg flexed on the thigh, the limb is to be carried up to a right angle with the pelvis; then, being held as before directed, it is first to be abducted and rotated inward, next carried across the abdomen toward the opposite side, and then finally brought down into a position of adduction, alongside the other leg. The head of the bone, during these manipulations, may pass below the acetabulum and slip by it, thus establishing the conditions of an ischiatic or iliac luxation. This may be guarded against by the aid of an assistant, who, with his fingers, shall press the head of the bone upward as the limb is being carried across the abdomen, or the same result may be accomplished by placing a folded towel beneath the upper end of the femur and exerting upward traction upon it while the manipulations just described are in progress. If the accident in question should occur, then the proper procedure will be to resort to the manipulations recommended for either of the cases previously described.

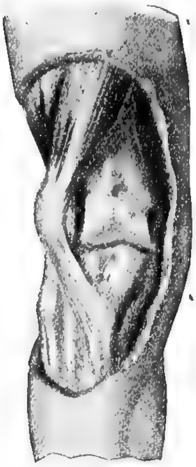

Fig. 1643.

Falling upon the foot or knee, when the thigh is drawn backward from a perpendicular, or violent twists of the limb, may dislocate the head of the femur forward and upward on the pubes, causing it to lodge internally to the pubic eminence. The limb will be shortened and abducted, the thigh flexed, the foot everted, and the trochanter less prominent, and the head of the bone will be apparent in front of the pubis. This dislocation is liable to be confounded with fracture of the neck of the femur. In pubic dislocation there will be absence of crepitus, immobility, abduction and flexion of the thigh; whereas in fracture there will be crepitus, increased mobility, and the thigh neither flexed nor abducted.

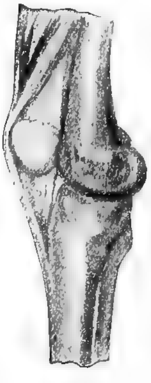

Fig. 1644.

For the reduction of this dislocation the leg must be flexed upon the thigh, and the thigh carried forcibly up to the abdomen until it rests in contact with it, thus relaxing the "Y" ligament and lifting the head of the bone off the pubis. As the next step the thigh must be rotated inwardly, and then, during adduction, the limb must be brought down toward and parallel with its fellow. If the luxation is suprapubic, in carrying the limb from its abnormal position of abduction to that of adduction it is not necesssary to carry it so far across the body as in thyroid dislocation.

The suggestions as to after-treatment and in regard to ancient luxations, which were made in connection with the subject of dorsal dislocations, are equally appropriate for this as well as the other forms of dislocation of the thigh.

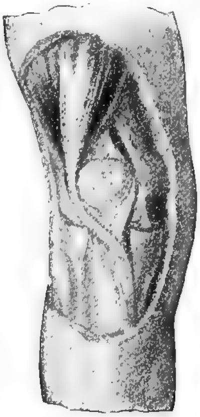

Fig. 1645.

Dislocations of the Patella are somewhat rare, and are due to sudden muscular contraction, to forcible torsion of the joint, or to the action of a force operating against one or the other side, the dislocations then being lateral. Separation of the tubercle of the tibia, or of the apex of the patella, may permit the bone to be displaced upward—a variety of displacement which partakes more of the nature of a fracture and requires the same treatment.

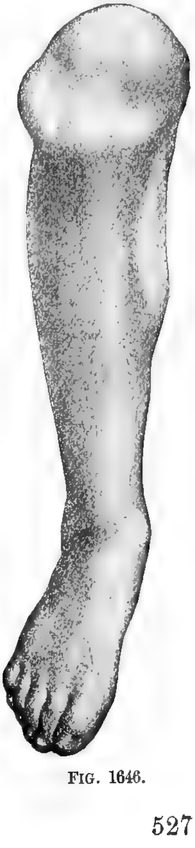

Fig. 1646.

In outward dislocation of the bone, which is the more frequent form, the breadth of the knee is increased, the internal condyle is prominent, the limb a little flexed, the joint fixed, and the borders of the bone may be felt as it lies in an antero-posterior direction toward the outer side of the joint. Reduction is usually easy, the bone sometimes slipping back unaided. If interference is needed, it will be found sufficient to flex the thigh to a right angle—the patient lying on the back, with the leg extended to relax the quadriceps tendon—and then to exert lateral pressure upon the joint.

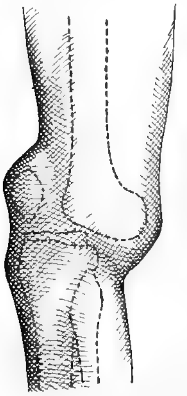
FIG. 1647.—Forward Dislocation of the Leg. (Helferich.)

In some cases the dislocation may consist in a partial or even complete rotation of the bone on its perpendicular axis. Under these circumstances the limb will be found in a position of complete extension, and there will be no difficulty in making out the position of the bone on account of its nearness to the surface of the skin. It may lie to either side or in front of its proper site. Rotary dislocations, as they are termed, require forced flexion of the thigh upon the abdomen, the leg being in an extended position; and if manipulation, on the part of the surgeon alone, fails to restore the patella to its natural position, the addition of alternate flexion and extension, to be carried out by an assistant, will aid the surgeon in his efforts to manipulate the bone back into its place with his fingers. After the patella has been reduced, the limb should be placed on a double-inclined plane for a week or ten days, or the knee should be fixed by means of a posterior splint or by a plaster-of-Paris dressing. For a week or ten days after the occurrence of the dislocation cold applications, in the form of an ice-bag, cold cloths, etc., should be made to the knee, or lead and laudanum should be applied, and then, after the temporary dressings are removed, a stout knee-cap should be worn for some time, the patient being cautioned as to the liability of a recurrence of the dislocation.

The Knee may be dislocated forward, backward, or laterally to either side. Forward dislocation may be complete or incomplete, and is the result of over-extension of the knee. In complete dislocation the leg will be shortened to an extent of from one to three inches, and may be extended or slightly flexed. The head of the tibia will be found to project in front, with the patella resting on it or in the depression above it, while the lower end of the femur will project backward.

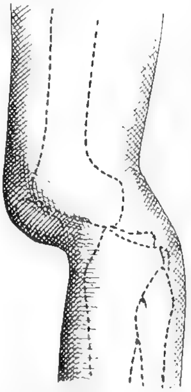
FIG. 1648. Backward Dislocation of the Leg. (Helferich.)

For the reduction of this dislocation anæsthesia may be required. Extension having been applied to the leg and counter-extension to the thigh, the patient lying on the back, the surgeon gradually flexes the leg over his arm and at the same time makes pressure forward in the popliteal space. For a period of a week or ten days, after the dislocation has been reduced, the limb should be placed on a well-padded posterior splint, and local applications of cold or of anodynes should be resorted to for the purpose of subduing inflammation. Then, for about three weeks, a plaster-of-Paris dressing should be employed; after which the patient should be allowed to use the limb cautiously, the joint being guarded or protected by some form of splint or brace.

In backward dislocation, which may be complete or incomplete, and is due to force applied to the front of the leg or to the back of the thigh, the patella is generally displaced in an outward direction, and the leg is in a condition of extreme extension, shortened, and it may be bent forward. The femur will be felt anteriorly, and the head of the tibia posteriorly. Extension and counter-extension with manipulation, at the hands of the surgeon, should suffice for reduction; the after-treatment being the same as in the former variety.

Lateral dislocations are generally incomplete, and if complete they are very apt to be compound. The patella is displaced and there is a laceration of the lateral as well as the crucial ligaments. There is no shortening of the limb, which is generally extended. Reduction is usually accomplished without difficulty by extension and counter-extension, combined with manipulation of the bone in the proper direction. The after-treatment is the same as in the other forms of dislocation of the knee.

In order to overcome the contraction of the powerful muscles of the limb, anæsthesia may be required in all dislocations of the knee. Extension and counter-extension by means of mechanical devices, as well as forced flexion and slight rotary movements of the tibia, may also be needed; yet we must bear well in mind at all times, in carrying out these procedures, the possible danger of seriously injuring the popliteal vessels. As a matter of fact this very injury may have already occurred at the time of the accident.

In rare instances the head of the tibia may be twisted outward or inward, and when the attempt is made to reduce the dislocation it will be found necessary to rotate in the opposite direction while extension and counter-extension are made.

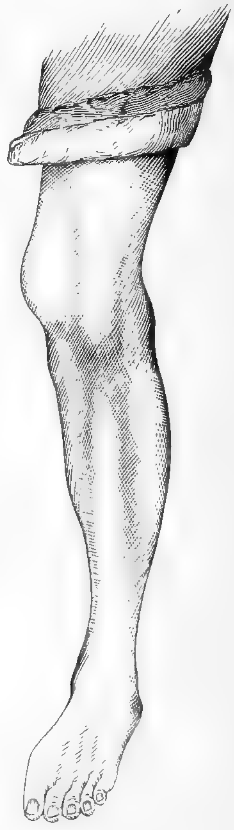
FIG. 1649.—Incomplete Outward Dislocation of Tibia.

Compound dislocations of the knee require the most thorough attention to aseptic details and possibly also to drainage. After reduction has been effected it will be necessary to apply an immovable straight dressing. In some cases it may even be necessary to resort to partial or complete excision of the joint. If ankylosis develops, the limb may be permitted to assume a position of slight flexion.

As a result of a sudden twisting of the leg, when semi-flexed, the semilunar cartilages may be forced from their natural position. Twisting the leg outward will displace the internal cartilage, while torsion inward displaces the external. The first indication of the fact that this has occurred will be a sharp, sickening pain in the knee, immediately following, in some cases, a perceptible snap. The knee remains fixed in its semi-flexed condition, and the cartilage may present an elevation on the outer or inner aspect of the knee—except in those cases in which the anterior edge is torn away and undergoes displacement inwardly toward the middle line, when there will be a slight depression opposite it. Recurrence is common. Reduction is effected by increasing the flexion and rotating the leg to the side of the displaced cartilage. If this does not succeed, flexion may alternate with slight extension and rotation. Synovitis, mild or severe, will follow, and rest of the joint, with local measures to combat inflammation, must be resorted to. If a well-made knee-cap fails to secure the retention of the cartilage in its proper place, and if in consequence much inconvenience results, it must be removed under strict asepsis. Attempts at fixing it by other operative procedures will prove only annoying and futile.

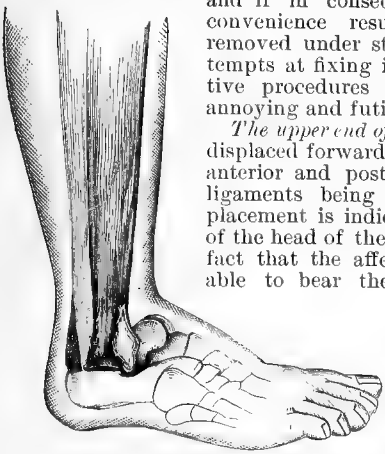
FIG. 1650.—Forward Dislocation of the Tarsus.

The upper end of the fibula may be displaced forward or backward, the anterior and posterior tibio-fibular ligaments being torn. This displacement is indicated by mobility of the head of the bone, and by the fact that the affected limb is unable to bear the weight of the body. By flexing the leg upon the thigh and thus relaxing the biceps, the head of the bone may be pushed into place. A moulded leather, gutta-percha, or binder's-board splint with a compress placed over the head of the bone, or a plaster-of-Paris dressing, should be applied; and in some cases it will be found necessary for the patient to wear such a dressing permanently.

The lower end of the fibula may be torn from its attachments and the foot displaced backward. By extension of the foot and manipulation the bone may be replaced, and maintained in its proper place by a fixed dressing of plaster of Paris or other material.

Dislocation of the Ankle, unaccompanied by fracture, is extremely rare, and is caused by a violent movement of the limb when the foot is fixed. It may occur in a direction forward, backward, or laterally.—In forward dislocation the foot will be lengthened and the heel shortened, while the tendo Achillis, resting against the tibia, will have lost its prominence. (Figs. 1652 and 1653.) For the reduction of this dislocation the leg should be flexed upon the thigh, in order to relax the soleus and the gastrocnemius; then extension should be applied to the foot and counter-extension to the knee. In some cases an anæsthetic may be needed, and possibly also subcutaneous section of the tendo Achillis. The foot should be kept at rest, with temporary splints, until the swelling has subsided; after which a plaster-of-Paris dressing may be applied.—In backward dislocation the foot, while in an extended position, may, through the action of some violent force, be drawn backward, until the tibia rests upon the neck or head of the astragalus, or upon the scaphoid or even as far forward as the cuneiform bones. (Figs. 1654 and 1655.) The foot will then appear shortened from the ankle forward, and the heel will be extended and elevated. At the same time the tendo Achillis will be unusually prominent and the toes will point downward. For the reduction of this dislocation counter-extension must be made from above the knee by an assistant, while the surgeon makes traction upon the foot and extends it with one hand, and with the other pushes the lower end of the tibia back. The after-treatment is the same as that advised for forward displacements. Section of the tendo Achillis facilitates the reduction and lessens the tendency to subsequent displacement.

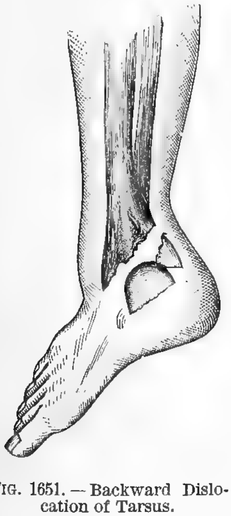
FIG. 1651.—Backward Dislocation of Tarsus.

In outward dislocation at the ankle we have marked eversion of the foot and prominence of the internal malleolus, the foot resting on its outer border. The deformity is the same as that of Pott's fracture, with which it is usually associated.

In inward dislocation, which occurs more rarely, the foot is inverted and the external malleolus is more prominent. In reducing it the surgeon must make extension from the foot and counter-extension from the leg, in combination with such manipulations as may be found necessary.

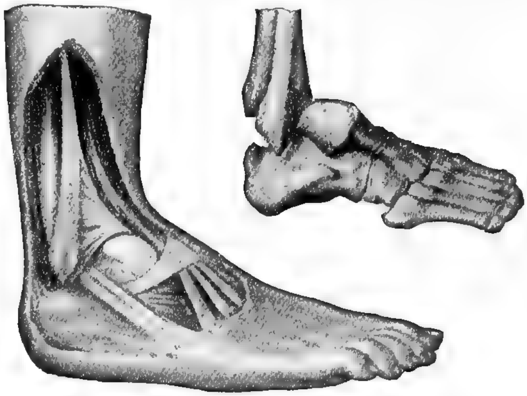
FIG. 1652. FIG. 1653.

FIGS. 1652 AND 1653. Forward Dislocation of the Foot, the Front Part Appearing to be Lengthened Whilst the Heel Does Not Project to the Normal Extent.

If fracture accompanies the dislocation, which is the rule, we shall have crepitus, immediate recurrence after reduction, and the other signs of fracture accompanying the deformity of the peculiar dislocation. The after-treatment in all cases is similar to that needed for fracture. Temporary dressings are to be applied until all swelling and inflammation have subsided, and then the plaster-of-Paris or other dressing of a permanent character may be used.

In compound dislocations the following measures are of importance: thorough asepsis, free drainage, and excision, partial or complete; and if there is much suppuration, which must be carefully watched for, irrigation will be required.

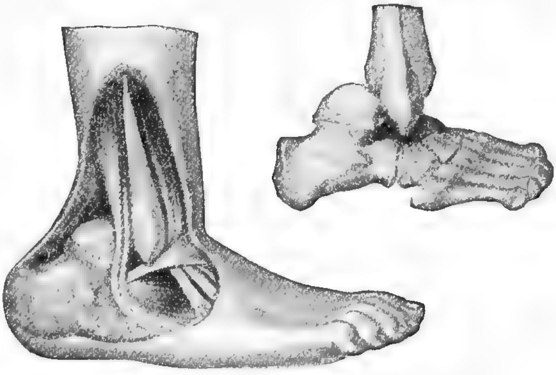
FIG. 1654. FIG. 1655.

FIGS. 1654 AND 1655.—Backward Displacement of the Foot, the Peroneal Tendons Being Placed Between the Astragalus and the Malleolus, and the Foot Apparently Shortened Whilst the Heel Projects Abnormally.

The Astragalus may be dislocated forward, backward, or laterally, or it may be rotated on its axis. In forward dislocation, which may be complete or incomplete, the foot is generally inverted with the external malleolus prominent, and with an irregularly shaped prominence in front of the ankle. By flexing the leg upon the thigh and then resorting to extension and counter-extension from the foot and leg, the surgeon may be able to push the bone back into place. In some cases it may be necessary to divide the tendo Achillis or to resect the bone.

In posterior displacement the foot is shortened, the heel is prominent, and the tendo Achillis is stretched over the projecting end of the bone. Reduction may be accomplished by extension and counter-extension from the foot and leg. The latter, however, must first be flexed on the thigh, and in his manipulations the surgeon must push the bones of the leg backward and pull the foot forward. Anæsthesia may be required, and even with this assistance all efforts may prove ineffectual. In some of these cases, however, the foot may prove to be comparatively useful despite the deformity; in others it will be found necessary to resort to excision.

Lateral dislocations are, as a rule, associated with fracture of one or the other malleolus, and efforts at reduction, similar to those already cited, may be tried.

Dislocation by rotation is extremely rare. The astragalus, which occupies a position between the malleoli, may be turned vertically or transversely. There will be fixation of the ankle with change in its shape. Extension and counter-extension, with manipulation and even section of the tendo Achillis, may fail to restore the bone to its place, and excision may then be required.

The after-treatment, in these luxations, should be the same as that advised in the paragraph relating to the after-treatment of compound dislocations.

In subastragaloid dislocations we have the astragalus separated from its articulations with the scaphoid and os calcis, while yet retaining its connections with the bones of the leg. These dislocations result from the same causes as those which produce true dislocations of the astragalus; they may also occur in the same directions as the latter. As regards the diagnosis and treatment nothing additional needs to be said. If the injury is compound, amputation may be essential, either by Syme's or by the subastragaloid plan.

The Os Calcis becomes separated from the astragalus above and the cuboid in front only in rare cases. The heel will be distorted, and there will be inability to abduct or adduct the foot. This dislocation, which is easily recognized, will require anæsthesia and manipulation and pressure for its replacement.

Dislocation of the Scaphoid is also a rare accident and will be recognized by its projection on the anterior surface of the foot. By making traction on the metatarsus the bone may be pressed back into place.

The Cuboid may be dislocated in connection with the other tarsal bones, but an independent luxation of this bone has not been reported.

The Cuneiform Bones may be dislocated separately or as a whole. By exerting force upon the metatarsal bones in an outward direction, they may be pushed into place. All these injuries require a temporary fixed dressing until swelling subsides, and then the foot may be put up in a permanent fixed dressing, which should be worn for four or five weeks.

Dislocation of the Metatarsals and Phalanges of the Foot occurs much more rarely than it does in the case of the corresponding bones of the hand. The diagnosis is easy, and reduction is to be accomplished by the ordinary measures of manipulation and extension, though the task is more difficult in the case of the foot than in that of the hand. After the dislocation has been reduced a fixed dressing of plaster-of-Paris or a moulded splint of leather, gutta percha, or binder's board, should be worn for several weeks, to secure apposition and rest.

Duncan Eve.

DISSECTION AND OPERATION WOUNDS.—The class of wounds to be considered under the title are those wounds received in the course of surgical operations, or of post-mortem or other anatomical dissections, which induce in the wounded subject a more or less grave condition of local or general sepsis. Such wounds are generally received upon the hands or forearms, but, except in unimportant particulars, the seat of the original infection has no special bearing upon the course or the character of the ensuing disease, which, when it passes beyond the status of a local inflammation, is essentially a pyæmia, a septico-pyæmia, or a septicæmia, differing in no essential respect from these diseases occurring as the result of infection received in divers parts of the body, and in the pursuit of the most varied occupations.

A. Etiology.—In investigating the etiology of dissection and operation wounds, a microbial origin will be taken for granted without further discussion, and we shall proceed to consider, first, the nature of the infecting microbe; secondly, the effect upon its virulence of the source from whence it comes; and thirdly, the different types of disease the various infecting germs are prone to engender.

(*a*) *The Nature of the Infecting Microbe.*—That the foremost place as an infecting agent is to be assigned to the Streptococcus pyogenes, is to be inferred from our knowledge of septicæmic and pyæmic processes in general, induced through other means than by the performing of surgical operations and anatomical dissections, rather than to be gathered directly from the somewhat sparse records in medical literature of cases in which a bacteriological examination "en règle" has been reported. One decisive case of streptococcus infection is recorded by Harrington,[1] and is reported below.

The Staphylococcus pyogenes aureus is, probably, the next most frequent organism which can give rise to the septic processes we are considering. Though sometimes found in pure culture, it is perhaps still more frequently found in association with the preceding.

It is hardly to be doubted that any and all of the well-recognized "pyogenic" germs may, under favorable circumstances, give rise to a more or less virulent septic process, if inoculated on the hands of the surgeon or the pathologist, but the literary sources are not at hand to enable me to verify this at the present writing. Furthermore, the minor pyogenic germs, Staphylococcus albus, citreus, cereus flavus, epidermidis albus, etc., do not ordinarily manifest a sufficient degree of virulence to occasion severe dissection or operation wounds, even though they may sometimes cause some local inflammation.

Outside of the germs more frequently included under the head of "pyogenic," the anthrax bacillus may be mentioned as one apt to occasion a condition which would properly come under our title. I have no record of a case in which anthrax infection has occurred either during a surgical operation or during a post-mortem examination, yet Gaston alludes, rather indefinitely, to a case in which inoculation with anthrax occurred as the result of the breaking of a culture tube containing the bacilli.[2]

The bacillus of malignant œdema, which in many respects closely resembles that of anthrax, would likewise seem peculiarly apt to cause infection of operation wounds; yet we have the authoritative statement of Welch (1895) that "no instance is recorded of infection of a previously healthy person with this bacillus."[3] One of the French names for the disease it induces, "gangrène foudroyante," describes a condition occasionally characterizing dissection and operation wounds.

The Bacillus tuberculosis is notoriously the occasion of infection in the so-called "anatomical tubercle," or "necrogenic wart," which is prone to appear on the hands of those frequently employed in the dissecting-room. The occurrence of a local or general tuberculous process as the result of an infection during a surgical operation I have not been able to find recorded, but both local and general tuberculosis, arising from accidents to the fingers and hands in the bacteriological laboratory, are believed to be not uncommon.

The Bacillus coli, the Diplococcus pneumoniæ, the gonococcus, the bacillus of Eberth, have been known to cause pyæmic abscesses and have been found in the blood in some forms of septicæmia; that they should, however, gain access to the tissues during operations or post-mortem examinations, and be able to multiply there in such a way as to occasion sepsis, seems, on the whole, unlikely.

The Klebs-Löffler bacillus, or Bacillus diphtheriæ, has frequently been the occasion of more or less severe diphtheritic processes following inoculations acquired during professional attendance upon diphtheritic patients. In one instance under the writer's observation, a sluggish and painful ulcer of the eyelid, which yielded a pure culture of this organism, followed an examination of a child's fauces, in which the patient had coughed in the face of the physician at the moment of the examination.

The virus of syphilis has repeatedly evoked a primary chancre on the hands and fingers of surgeons.

In many cases, as notably in that of Professor Park, detailed below, it has not been possible to identify the infecting agent, and in many cases also a mixed infection has been passed on from the patient to his physician, or has been acquired during the performance of autopsies.

(*b*) *The Effect upon the Virulence of the Infecting Germ of the Source from Whence it is Derived.*—Accurate statistical information on this particular branch of our investigations I have not had the opportunity to collect; indeed, the sparse records of dissection and operation wounds to be found in medical literature, of sufficiently recent date to throw any valuable light on this question, are remarkably deficient in their reports as to this phase of the problem. In considering the enormously enhanced virulence of the pathogenic organisms which we occasionally encounter in dissection and operation wounds, we are again driven to inferences derived from observations of the broad and complicated subject of the virulence of pathogenic bacteria in general, and I must content myself with some suggestions as to possible conditions which may enhance the virulence of the germs in question, rather than proceed to report a categorical list of recorded cases.

I would call attention, in the first place, to the means commonly made use of in the bacteriological laboratory to exalt at will the virulence of any given form of pathogenic germ, namely, the expedient of passing the organism through the body of a susceptible host. Particularly are the streptococci thus susceptible of manipulations calculated to enhance their virulence. To cite but a single instance of a well-known procedure, Denys and Marchand, in studying the Streptococcus pyogenes,[4] procured samples of these germs from four different sources, all four of very slight virulence, and for the purpose of comparing the effects of the inoculation of mild cultures with those of virulent cultures, multiplied the virulence of the original cultures by this means, until the increase in virulence, as measured by the size of the minimum fatal dose, was expressed by a factor not less than 10,000. Nothing, however, is ordinarily more difficult than to maintain this condition of exalted virulence in cultures grown in artificial media; each successive generation grown "in vitro" showing a great and progressive diminution in virulence.

Now it is this well-known attribute of the pyogenic bacteria which affords us a key to the enormously exaggerated virulence sometimes evident in the infecting agents of dissection and operation wounds.

We are daily made familiar with the occurrence of sepsis, more or less profound, occasioned by the infection of slight abrasions and minute wounds of the fingers and hands with pyogenic cocci inoculated upon these wounds from contact with inanimate objects; this "filth infection" may be very severe, and is occasionally fatal.

Let us once consider a case in which pyogenic bacteria, streptococci, if you choose, growing upon a splinter of wood, constitute a source of infection which we will call A; let us suppose that a mechanic infects his hand from this splinter of wood, and becomes himself, through the means of a "cellulitis" induced by these streptococci, a second source of infection, B. Let us further suppose that a culture is made from the mechanic's wound; after this culture has grown a certain length of time in a test tube, this becomes a third source of infection, C.

Now let us examine the comparative virulence of the three sources of infection: A, the "filth-infection"; B, the "direct infection"; and C, the "test-tube infection." The virulence of A we know, for we have just supposed it to have produced a more or less severe cellulitis on the hand of the mechanic. Let us suppose now, further, that the surgeon who dresses the mechanic's hand himself receives a minute scratch in the operation, and that this scratch is directly infected from the source B; the presumption is that a severe, possibly a fatal, septic process would develop in the person of the surgeon. Again, let us suppose that the bacteriologist (he, the surgeon, and the mechanic being equally robust men, with normal powers of resisting infection) breaks his test tube and cuts himself with the glass, infecting himself with the same germs, but from source C; the presumption, in this case, is that he would suffer from a septic process approximately equal in severity to the cellulitis on the hand of the mechanic; *i.e.*, in undergoing culture on an artificial medium, the septic germs would be liable to lose again the increment of virulence which they may be supposed to have acquired in passing through the human body; but, as we have seen in the case of the surgeon, direct inoculation from the septic focus on the hand of the mechanic manifests a very decided increase in the virulence of the germs, an increase acquired by their passage through a susceptible host.

This is what I conceive to be the essential difference, as far as an essential difference may be conceived to exist, between an ordinary case of septic infection and a "dissection or operation wound."

When we dwell upon the numerical size of the factors by which the virulence of a given germ may, under some circumstances, be multiplied—10,000; 100,000; or even 1,000,000,—we can form a conception of the extreme degree of virulence which some cases of direct infection, from man to man, may present.

The cruder ideas of wound infection, as being analogous to the simple process by which a sterilized infusion undergoes putrefaction when a single suitable germ is introduced, have been superseded, now that fuller investigation has shown the elaborate means of defence with which our bodies are provided to enable them to ward off the deleterious effects of pathogenic germs; and we can now better appreciate what powers of noxious influence a germ must possess which succeeds in overcoming all these barriers, and in accomplishing the undoing of a man or an animal.

It is a well-known biological law that exaltation of functions comes from their successful exercise. We speak of the acquired immunity of a man or of an animal to the noxious powers of certain germs, and we understand thereby that his defensive proteids either are present in greater quantity, or have acquired a higher potency. It is just as logical, however, to speak of the acquired immunity of a germ to the (to it) noxious powers of the human or the animal cells, and we may properly understand thereby that the analogous proteids of the bacteria, what we may call the "offensive proteids," either are formed in greater relative quantity, or have acquired a higher degree of virulence. Just as a man who has successfully struggled with the germ of typhoid fever is generally immune to attacks of the bacilli typhosi in the future, so a streptococcus which has succeeded in vanquishing the opposition to its development offered by the cells and the alexins in the serum of a human body may be conceived to carry with it an "acquired immunity" to the influence of such cells and such serum, if it pass directly from one human subject to another. And the more complete the victory of the germ over the human body cell, the more complete the "immunity" acquired by the germ against the defences of the human organism; and, ergo, the more apt is the germ to induce a grave type of infection, always provided the transmission is direct from one human host to another. Now, by way of illustration, bone marrow has been ascertained, by Wauters, to contain larger proportions of bactericidal substance than any other tissue of the body;[5]

we may thence infer that bacteria which have succeeded in gaining a foothold in the bone marrow itself will be found to be possessed of a high degree of virulence, and we may accordingly expect to find, as indeed we do, that direct infection from a case of acute osteomyelitis will be apt to be very grave. Again, the highest stage of the triumph of pyogenic germs over the animal body is seen in the conditions known as septicæmia and pyæmia, and it is in just these cases that we find the danger of direct inoculation at a maximum.

In further support of this argument, as tending to show its converse, we may mention the fact that often, in cases in which the human or the animal organism is ultimately victorious over the germ infection, it is found that cultures taken at the beginning of the struggle are more virulent than those taken from the same case later on in its course, when a portion of the virulence of the infecting organisms seems to be overcome; *e.g.*, a beginning carbuncle may afford germs of far greater virulence than one over which the defences of the organism have in a measure successfully asserted their power.

We can now understand why it should have been universally observed that inoculations from severe septic cases are more prone, than those from the lighter forms of sepsis, to give rise to the type of surgical disease which is the subject of this article. Puerperal fever, pyæmia, septicæmia, carbuncles in their acute stage, malignant erysipelas, acute osteomyelitis, phlegmonous cellulitis, and suppurative peritonitis are most frequently named as the origin of dissection and operation wounds, whether from surgical operations proper, from surgical dressing, or from post-mortem examinations. These germs, when inoculated directly from man to man, occasionally, even if rarely, acquire an enormously enhanced virulence, exhibited at its maximum, however, only in cases of direct inoculation. Infected knives, sponges, dressings, or other objects may indeed carry the infection for some days, or even weeks, if not properly disinfected, but it is probable that the full degree of virulence that attends direct inoculation at the time of operation, or at the moment of a post-mortem examination, would not be manifest in an infection conveyed by the same germs at a later period, after the lapse, that is, of an interval during which the germs, even if surviving, were exposed to influences, such as desiccation or chilling, comparatively unfavorable to their existence, or at least to the maintenance of one of their more unstable characteristics, their virulence.

On this same basis, likewise, is to be explained the notable difference in the comparative danger of a wound received at a recent, with one received at a delayed autopsy. In the first case, the remaining bodily warmth, and the absence of the further development of the defensive proteids on the part of the dead subject, allow the bacteria to develop under conditions most favorable for their growth; in the second case, the chilling of the body, and, likely enough, the beginning decomposition of the tissues, and the struggle for existence with saprophytic bacteria, so affect the environment as to yield a less suitable culture medium for the pyogenic germs, which, continuing indeed to grow, yet develop under less favorable circumstances, and consequently lose that acme of virulence which manifests itself only under peculiarly favorable conditions of growth.

A phenomenon analogous to the greater danger of direct, man-to-man infection as compared to indirect, filth infection, lies in the well-known occasional virulence of the bites of animals. Here, too, septic conditions are sometimes communicated in which germs are directly transferred from one host to another, in a condition of "exalted virulence"; indeed, the bite of a man is not less dreaded than that of some of the lower animals.

Cases of exalted virulence of the infecting germs, due to direct transference, were not infrequently seen when "arm-to-arm" vaccination was still in vogue, where apparently healthy children communicated severe disease to others.

The experiments of Fehleisen tend to show another reason for the greater danger of "direct inoculation" as compared with "filth infection." This observer[6] showed that a minimal quantity of an artificial culture of staphylococcus aureus added to a little of the clear serum obtained from the germ-free zone of inflammatory œdema around a spreading cellulitis, was capable of producing extensive abscesses, whereas the mixture of the same organism with water had no effect. The inference is that the bacteria, in the first case, were accompanied by their toxins, and entered the contest armed, as it were, for the fray; while in the second case, the bacteria were washed free from their toxins, and were unable to gain a foothold in the tissues until their toxins were again secreted in sufficient quantity to weaken the defence of the tissue cells; in the case of these particular experiments, the staphylococci employed were unable to do this in time to prevent their destruction by phagocytosis. Now, in cases of direct inoculation, the bacteria will be more likely, than in cases of filth infection, to be accompanied each with its minute quantum of toxins, which will enable them to increase and multiply, where similar germs, without the accompanying toxins, would be exterminated.

In conclusion let me say that to ascribe, as some were inclined to do, when the germ theory of disease was younger, a special and peculiar infecting agent to dissection and operation wounds, on account of their occasional extreme virulence, is entirely gratuitous and uncalled for. Ample explanation can be given for all the phenomena observed, if we distinguish clearly between the differing possibilities of gravity in cases of direct inoculation, as compared with ordinary filth infection.

Having now considered the nature of the germs which give rise to dissection and operation wounds, and the effect upon the virulence of the infecting germs of the source from which they are derived, it now behooves us to consider:

(*c*) *The Types of Disease These Infecting Germs are Prone to Engender.*—Of the germs which were mentioned under (*a*), as possible causes of dissection and operation wounds, it is unnecessary to describe the type of disease which would be likely to follow the inoculation of the more specific forms; the anthrax bacillus, the bacillus of malignant œdema, the tubercle bacillus, and the Bacillus diphtheriæ would all of them be likely to give rise to more or less characteristic lesions, whose description may be sought under the appropriate headings elsewhere in this work. The virus of syphilis would give rise to a hard chancre. Indeed it is doubtful whether the lesions which these germs produce are properly classed under our heading, and they are mentioned rather for the sake of rounding out the subject than for their actual importance as frequent causes of dissection and operation wounds; and we shall not have further occasion to consider them here, as we shall confine our future discussion to lesions caused by the "pyogenic" germs proper, whether in pure or in mixed infection.

Now the name "pyogenic" implies that the most characteristic result of infection with these germs is the formation of pus; yet though this is the characteristic outcome of such infections, this result does not always follow, nor yet is its appearance, in any true sense, a measure of the virulence or of the gravity of the infection. Suppuration, indeed, represents the most intense and complete *local* action of these bacteria, but the less advanced forms of inflammation are always precedent stages of suppurative action, and very extensive and dangerous lesions may fatally compromise the vitality of the patient without the presence of pus in any one focus; this, too, with staphylococcus infection, with streptococcus infection, and with mixed infections of the two germs. Says Welch: "All of the affections caused by one species of the pyogenic cocci may be caused by any of the others. For example, the Staphylococcus aureus may produce spreading phlegmons, inflammations of serous membranes, puerperal infections, general septicæmia, as well as the Streptococcus pyogenes, and the Streptococcus pyogenes may cause circumscribed abscesses and osteomyelitis, as well as the yellow or white staphylococcus. Jordan claims that the Staphylococcus aureus may cause erysipelas, but Petruschky does not regard his observations on this point as conclusive."

"Furthermore, these pyogenic staphylococci and streptococci may cause all kinds of inflammation besides the suppurative. They may, and often do cause serous, sero-fibrinous, and fibrinous inflammations of serous membranes. The Streptococcus pyogenes may cause catarrhal and fibrinous inflammations of mucous membranes. Pyogenic cocci may be the sole cause of simple inflammatory œdema or serous infiltration of the tissues. They are sometimes found in cutaneous vesicles and blebs containing clear serum. They may be the sole organisms present when the inflammatory exudate is hemorrhagic. They may produce extensive necrosis of the tissues with scarcely any inflammatory exudate. We find the same staphylococci and streptococci in those rarer forms of osteomyelitis which do not suppurate, as in the ordinary suppurative form. They are the usual cause of periostitis and ostitis albuminosa, in which the exudate is serous. A serous or sero-fibrinous inflammation caused by pyogenic cocci may be transformed into a purulent one without the appearance of any new species of micro-organism." [7]

While we recognize, as above related, the great variety of lesions to which the pyogenic cocci may give rise, and also the fact that any of these protean forms of disease may, with the possible exception of erysipelas, be occasioned either by the Staphylococcus aureus, or by the Streptococcus pyogenes, or by a mixed infection of both germs, yet, nevertheless, the more typical characteristics of infection by one of these germs, as distinguished from the other, can very often be made out. It is the general tendency of the staphylococcus to form circumscribed abscesses, surrounded by a distinctly marked zone of dense inflammatory exudate; while it is equally the tendency of the streptococcus to excite spreading phlegmonous processes along the connective-tissue planes, and to invade the lymphatic vessels and glands.

Mixed infections of the two cocci may take on the characteristics of both, or may follow the type of either one Mixed infections, when either the staphylococcus or the streptococcus is in combination with some other non-pyogenic form of bacteria, may follow either the staphylococcic or the streptococcic type, or may present a more confused type of inflammation. The importance of distinguishing, if possible, the cause of the infection lies in its bearing on the prognosis, which becomes most grave in the presence of the streptococcus.

B. PATHOGENESIS.—We shall consider under this head, first, the type of wound by which infection is prone to occur; secondly, the condition of the constitution which favors spreading of the infection; thirdly, the various forms of internal resistance offered to the advancement and multiplication of the microbes; and, fourthly, the means of eliminating the microbes and their products from the system.

(*a*) *The Type of Wound through which Infection is Prone to Occur.*—As a matter of fact, the wounds through which septic infection has been received during the performance of surgical operations and post-mortem examinations, have been, for the most part, in themselves most trifling; generally slight scratches or abrasions, superficial cuts, punctures from needles, and, in a not inconsiderable proportion of cases, lesions either literally microscopic, or so small as to defy discovery after minute examination.

Inasmuch as other types of wounds, as a matter of fact, do not occur under the circumstances, we are not able to institute comparisons between the behavior of one type or of another type of operation wounds, but there are some reasons which lead us to suppose that the type of wound ordinarily received during surgical operations and post-mortem examinations is not without influence upon the subsequent development of sepsis in their recipients. Two reasons would lead one *a priori* to suppose that the class of wounds described above would be more prone to permit the development of severe sepsis than deeper or more extensive traumata, and of these the first has reference to their *superficial position.*

Especially in cases of slight abrasion of the skin, the infecting bacteria are apt to be implanted directly into the cutaneous lymph channels. Now three several circumstances combine to make such a lodgment of the bacteria one particularly favorable to their subsequent development. First, the most dreaded type of infecting germ, the Streptococcus pyogenes, has notoriously its favorite habitat just here, as it will be remembered that not only does the streptococcus tend in general to accumulate particularly, and sometimes almost exclusively, in the lymph spaces, but that the invasion of the cutaneous lymph spaces is *par excellence* the attribute of this streptococcus, which is now generally conceded to be identical with the Streptococcus erysipelatis of Fehleisen.

Secondly, aside from the specific type of the infecting germ, experiment has indicated, with other forms of bacteria also besides the streptococci, that actual infection of the organism occurs via the lymph channels. The following experiments have been instituted to demonstrate this conclusion [8]: Rabbits were first inoculated on the tip of one extremity with anthrax cultures, and observations were made as to the length of time necessary for the bacilli to reach the lymph glands; a certain number of observations established more or less exactly the time necessary for this to occur. The extremities of other rabbits, similarly inoculated, were amputated before the lapse of the minimum time necessary for the anthrax bacilli to reach the lymph glands; these animals survived, while those whose extremities were amputated after the critical time perished. The inference drawn is that infection must occur through the lymph channels and not through the sanguineous circulation, else amputation of the extremity had not rescued the inoculated animals. Though this can hardly be said to constitute rigid proof that pyogenic infection constantly occurs in this way, yet it gives ground for the suggestion that a slight abrasion opening the lymph channels without affecting directly the deeper tissues might afford an exceptionally favorable portal of entry to septic germs. The experience of public vaccinators in general would seem to support this same idea, inasmuch as they assure us that vaccination is far more likely to "take" if the scarification of the skin, for the purpose of introducing the vaccine, is not made sufficiently deep to occasion actual bleeding.

The third circumstance, which makes a superficial wound or abrasion one which is prone to septic involvement, is the circumstance that, from the mere fact of its superficiality, it is in a measure removed from the defensive apparatus of the animal economy, and germs there entering are less freely exposed, than those deeper ensconced, to the protective influences of chemotaxis and phagocytosis. Germs implanted in the connective tissue proper have far less chance of survival than those introduced directly into the cutaneous or other lymphatic channels. Not only the observations of Wauters, already referred to above, but those also of Marmorek and of others, have established the fact that the connective tissue is the most efficient defender against bacterial invasion, owing largely to the fact that this tissue contains in itself a comparatively high proportion of actively bactericidal substance. But Marmorek further asserts that the observed fact of the unstable foothold obtained, as a rule, by pathogenic germs in many parts of the body, depends not only on a special antibacterial force, but is also in close relationship with strictly anatomical conditions. When the bacteria have once succeeded, owing to the prevalence of their virulence or of their number, in overpassing the zone of protective infiltration in the connective tissue, they have, *ipso facto*, overcome the "first system of defence" at that point. They then, at length, obtain a foothold in a lymph vessel, and thence extend themselves to the lymph glands; the lymphatic system he regards as the organ of the "second line of defence." [9] Thus, pyogenic germs inoculated immediately into the cutaneous lymphatics are introduced within, or we may say behind, the outer defences of the body, and so are, in a measure, relieved of a portion of the combat for supremacy with the cells of the animal microcosm.

The second reason which should render wounds of the type ordinarily received during surgical operations and post-mortem examinations specially prone to septic involvement, is the fact that they are likely to present a maximum of virulence, in conjunction with the important condition of a minimum of mechanical or chemical trauma. Trauma elicits inflammation, which is substantially the sum of those actions by which the animal organism brings into play its defensive apparatus against microbial or other harmful invasion. Diapedesis, serous effusion, fever, and pain (inducing immobilization of the affected part) are defensive means spontaneously brought into play in the presence of any extensive trauma; all these are far less active in the case of minute wounds, than in that of injuries of greater magnitude. The relation between the extent of the local reaction at the point of inoculation on the one hand, and the duration of life and number of organisms present in the blood on the other, have long been recognized in the experimental septicæmias of the lower animals.[10] Just as we find that many of the defensive proteids, the so-called "phylaxins" (the mycophylaxins and the toxophylaxins) are not manufactured by the animal organism except in the presence of bacterial onslaughts, so it is not unreasonable to suppose that certain of the "offensive proteids" of the invading microbes may not be manufactured by them, except in the face of opposition to their growth exhibited by the defensive activity of the animal cells, and that when these "offensive proteids" are not thrown out, a defensive chemotaxis is less actively evoked and the virulent bacteria, insidiously implanted, may continue to multiply unopposed, until they have acquired a reserve power for attack which they might never have attained had their inoculation been attended with more extensive traumatism.

(*b*) *The Condition of the Constitution which Favors Spreading of the Infection.*—The question of the condition of the constitution which favors the spreading of the infection in dissection and operation wounds is most intimately connected with the doctrine of mixed infections. Aside from the well-known fact that a generally debilitated condition of the body, such as is produced by insufficiency in food and rest, protracted anxiety and nervous strain, and prolonged exposure to cold and other influences more or less powerfully depressing to the resisting forces, and the coexistence of such disease as diabetes, syphilis, alcoholism, anæmia, obesity, typhoid and other fevers, Bright's disease, etc., some of which have been shown, upon most conclusive clinical evidence, to be predisposing causes of infection with the pyogenic cocci, we must give proper weight to the conditions of enhanced virulence that may develop as the result of the concurrent development in the tissues of two distinct forms of bacteria. Whereas this association may be without special influence as regards infection, yet more frequently the concurrent inoculation of two species of bacteria increases the danger from one or both. "A combination of two species, each in itself harmless, may prove fatal" (Roger). A bacterium of attenuated virulence may become augmented in virulence by inoculation in combination with another species, which need not necessarily be itself pathogenic, or sometimes simply in combination with the *chemical products* of another species.[11] Nor is it essential to the appearance of enhanced evil effects that the inoculation of such independent growths be simultaneous. There is no lack of clinical cases to illustrate the occurrence of severe pyogenic mixed infections, in which, in one set of cases, the pyogenic process was latent or in abeyance, and was roused to extreme or even fatal activity by the admixture of a fresh, non-pyogenic infection; and in another set of cases, a previously latent non-pyogenic infection, when later mingled with an infection of pyogenic type, gave rise to the gravest manifestations of sepsis. The influence, in this regard, of epidemic influenza has been recorded by Bennett, in four cases, which we can but briefly glance at:[12]

Case I. Simple synovitis of the knee, almost well, influenza, suppuration, pyæmia, amputation.

Case II. Cystitis, improved, urine suddenly excessively fœtid, after forty-eight hours of influenza, obstinate cystitis, pyæmia.

Case III. Patient apparently convalescent from influenza noticed swelling and redness about a small crack in lower lip. Erysipelatous inflammation followed, with abscess over right side of face and throat. A few days later, pneumonia and secondary pyæmic deposits over right knee and left thigh, followed by sudden filling of left knee joint.

Case IV. Urethral stricture, facial herpes followed by influenza, erysipelatous inflammation, pyæmia.

The influence, on the other hand, of a pre-existing stercoræmia, a "bad cold," or other mild, non-pyogenic infection, as a cause predisposing to pyogenic infection, is so generally recognized as to make any more specific citation of cases superfluous.

Now how frequently is the surgeon or the pathologist obliged to continue his work when himself suffering from many such mild ailments, yet how considerable a bearing they may have on the outcome of an accidental inoculation with pyogenic germs during operation or autopsy is scarcely appreciated until the unexpected happens, and a trifling injury is seen to take on all the aspects of a virulent local, or even general, infection.

(*c*) *The Various Forms of Internal Resistance Offered to the Advancement of the Microbes.*—It is not within the scope of this article to elucidate the whole pathogenesis of pyogenic infection, yet a proper understanding of the dire results which may follow upon a slight dissection or operation wound demands that we should at least briefly follow the history of the microbes which have been inoculated with the receipt of the wound.

The "cytomachia" which follows the introduction of pathogenic bacteria among the constituent cells of the animal or human economy, is but a single, limited, yet intensely interesting phase of the general biologic phenomenon of the struggle for existence. In one sense, indeed, it is the struggle of the individual animal, as a whole, against an opposing entity, the invading disease; yet in a sense equally true, but only appreciable to us since the recent advances of scientific investigation, it is the struggle of a countless number of individuals of an invading host, against countless numbers of individual cells acting on the defensive. Looked at from this latter point of view, it is a struggle of cell against cell and a crossing of cell weapon with cell weapon. The invading hosts are the pathogenic bacteria, and their weapons are, what I have ventured to call, the "offensive proteids." These "offensive proteids" have been ascertained to be of two kinds, the toxins, and certain proteolytic substances (ferments?), capable of causing the death and disintegration of the body cells, but yielded up only at the death of the individual bacteria. The defending hosts are the militant cells of the animal body, chiefly the leucocytes and certain comparatively undifferentiated connective-tissue cells, the so-called "Schlummerzellen," and the defensive proteids are of two kinds, the antitoxic proteids, directed against the "offensive proteids," *i.e.*, against the toxins (antitoxins); and the proteolytic (antimycotic) proteids (bacteriolysins), directed against the opposing bacteria, and capable, under favorable circumstances, of causing their death and disintegration. Besides this "long-distance" combat, the analogy with human warfare is still further borne out by the actual grappling of individual cell with individual bacterium. In some cases this represents the attack of the bacterium on the leucocyte (*e.g.*, the gonococcus); more often it represents the attack of the leucocyte on the bacterium, and the phenomenon is then known as phagocytosis.

In the conflict between animal cells and bacteria all these factors are simultaneously or successively brought into play, and certain forces prevail and predominate over other forces, until victory, at least temporarily, rests with one party or with the other.

According to the relative predominance of one or more of the embattled forces we have one or another pathological picture before us. One of the earliest and the commonest pathological phenomena which are observed to follow the invasion of the animal body by pathogenic germs, is active or inflammatory œdema. This is the result of what is known as chemotaxis, the marshalling of the forces of the defence; the leucocytes in vast numbers assemble on the field of battle to engage the invading bacteria.

Another common phenomenon is localized suppuration and abscess formation. Here the leucocytes have not only assembled but have actually engaged the bacteria, and with the death of their foemen, or of members of their own forces, there have been liberated the proteolytic substances which have caused the liquefaction of the surrounding tissues.

Though the pus within an abscess cavity may swarm with bacteria, yet not infrequently bacteria in such pus are few, or may be altogether absent, *i.e.*, the pus is "sterile" (suppurating buboes, tuberculous abscesses, gonorrhœal salpingitis, empyemic exudates). In the first case the abscess has been more or less immediately caused by the bacteria, and they have "slain their thousands" among the leucocytes, the bodies of the defunct leucocytes have become dissolved through the action of the proteolytic ferments, and only sparse, disembodied nuclei, but faintly dyed by staining reagents, are to be found in the fluid; such pus is thin and watery, it is spoken of as "ichorous" pus, and has long been recognized as "acrid," "erosive," and "virulent," *i.e.*, it contains many victorious bacteria. In the second case, on the other hand, the suppuration has been evoked more or less immediately by the leucocytes, which by an exaggerated chemotaxis have crowded about the invading bacteria and have overcome them, some by phagocytosis, some doubtless by means of the antimycotic proteids (mycosozins, mycophylaxins, bacteriolysins); such pus is thick and creamy, contains plump, distinctly nucleated "pus cells" (polynuclear leucocytes) and is known as "laudable pus," and recognized as far less virulent and acrid, *i.e.*, it contains few (sometimes none at all) debilitated and attenuated bacteria.

Another phenomenon occasioned by the invasion of the tissues with pathogenic bacteria is more or less extensive necrobiosis and sloughing. Here is a case in which the toxic influences of the bacteria have been locally exercised to a more extensive degree than the leucocytes immediately engaged have been able to cope with, and larger or smaller masses of the less energetically vitalized tissues, in the neighborhood of the focus of invasion, have been literally poisoned to death by the concentrated toxins. This is generally, but not always, accompanied by more or less suppuration of either the first or the second type; we deem it to be of the first type when the sloughing is progressive (necrosis progrediens); of the second more benign type when the sloughing is not progressive, but is rather the benign effort of nature to expel useless tissue by a process, as it were, of spontaneous amputation.

Again, in another case, the best efforts of the defending leucocytes are barely equal to the task of holding in check the local development of the bacteria, but the latter nevertheless produce their toxins in such quantity that the antitoxins of the animal cells (the toxosozins and toxophylaxins) are no longer sufficient completely to neutralize them, the unneutralized excess of bacterial toxins circulates in the blood serum, and the profound intoxication, which we saw involve the death of vulnerable tissues in the immediate neighborhood of the focus of invasion, exerts a similar, but happily generally a less intense, effect upon all the tissues of the organism; toxæmia is the result, with headache, vomiting, general malaise, and the system generally reacts against the wholesale poisoning of its tissues, with fever; yet in the more malignant intoxications such widespread and profound intoxication of the tissues may be produced that the individual succumbs at once, without any reactionary fever, without suppuration, sometimes even before marshalling of the forces of the defence by chemotaxis, "septicémie foudroyante"; the whole drama is ended in a few days or even a few hours, with a normal or even a subnormal temperature, and without reaction to the overwhelming dose of the toxins.

A still higher triumph of the invading bacteria over the defences of the body is manifested when the former not only send their unneutralized toxins coursing through the veins, but themselves escape bodily through the second barrier of defence constituted by the lymph channels and lymph glands, and, mingling with the blood corpuscles in the blood-stream, continue to grow there, and in the very bosom of the life fluid itself multiply their numbers and evolve their noxious products. This condition, that of septicæmia *strictiori sensu*, is most typically developed in the specific experimental septicæmias of the lower animals, in which, after the inoculation of the specific virulent germs, these are presently found swarming in countless numbers in the blood of the victims. In this aggravated form this invasion of the blood with pyogenic bacteria is rarely, though indeed occasionally, seen in man (*vide infra*, Case IV.), but in the human subject analogous symptoms are developed when even a few pyogenic cocci are discernible in the blood after careful examination. It would seem that bacteria having sufficient vitality to establish themselves and multiply within the blood are nearly beyond the reach of effective attack by the animal defences, and cases in which pyogenic cocci, especially streptococci, have been demonstrated in the circulating blood must be regarded as having a very grave prognosis, unless extraordinary aid can be afforded to the defensive apparatus of the patient. Nevertheless, battle is sometimes offered the pyogenic bacteria even within the blood-vessels, and the severe chills and enormous excursus of the temperature curve indicate the desperate character of the conflict waged by the defensive cells. The cells die in multitudes and in expiring bring into play their most powerful weapon, the antimycotic proteids (the mycosozins and the mycophylaxins and bacteriolysins). Now along with the leucocytes (the militant cells of the blood) numbers of the red blood corpuscles also undoubtedly succumb in conditions of severe sepsis, and a fibrinogenous substance, metaglobulin,[13] is developed, a product of the disintegration of cell protoplasm, which has the attribute of inducing coagulation of the blood and thrombus formation. In these thrombi the battle is renewed much as it was first fought in the connective tissues, and each separate thrombus becomes immediately invaded with septic germs, and becomes converted into a suppurating focus, a pyæmic abscess. As the invading bacteria successively invade each new thrombus, and cast a fresh load of toxins upon the staggering forces of the patient, the event is heralded with a chill, the characteristic phenomenon of a pronounced pyæmia. The struggle is now continued for a time, at an almost hopeless disadvantage, until death, either from exhaustion or in profound septic intoxication, closes the scene.

Leaving for other articles in this work to give the further details of the process of septic infection which we have thus broadly sketched, it must suffice us, in considering the development of dissection and operation wounds, to familiarize ourselves with the following general conclusions of Marmorek in regard to them, as a limited sub-class of general or local septic infections:

"Not only is it to be considered that all those diseases which are classed as septic are etiologically one and the same, and that one and the same bacterium can produce all of its forms, but we must also recognize that even the clinical pictures which they afford are capable of full and complete interpretation from the same etiological standpoint. All the manifold disease forms are simply the consequence of that variability of the different factors involved which the constantly changing relations between the invading forces of disease, on the one hand, and the resisting forces of the organism, on the other hand, occasion. Those conditions, which writers speak of as 'septic intoxication,' 'infection,' 'mycosis,' and pyæmia, are naught else but the results of infection, principally by one particular microbe, the Streptococcus pyogenes, and only occasionally by the Staphylococcus pyogenes aureus."

"Erysipelas, phlegmons, and carbuncles are forms of septic infection where the conflict is fought within the first system of defence of the invaded organism; in lymphangitis and lymphadenitis the conflict lies within the second system of defence; and septicæmia and pyæmia are evidences of conflict within the third and last means of animal defence, the blood itself."[14]

"When bacteria, possessed in a high degree of the faculty of manufacturing toxins, gain access to the organism, or when bacteria find within the tissues of their host conditions favorable to the abundant production of toxins, then the result of their invasion will be a toxæmia or a septicæmia; when these conditions favoring abundant production of toxins are wanting, the bacteria, provided they are nevertheless capable of maintaining and multiplying themselves, can work their noxious effects upon the organism only through the means of those proteids which are set free by the death of individuals among them, *i.e.*, the proteolytic ferments; the result is a pyæmia. Inasmuch, however, as in most cases toxin production and proteolytic-ferment production proceed side by side, a sharp line can never be drawn between toxæmia, septicæmia, and pyæmia." (Sitzmann.[15])

(*d*) *The Means of Eliminating the Microbes and their Toxins from the System.*—The active struggle between the invading bacteria and the defending body cells may have any one of three terminations: The active struggle may degenerate into a quasi "guerilla warfare," finding its expression in a tedious succession of smaller disease processes, the sequelæ of the disease inaugurated by the primary infection; or, the conflict may terminate in a truce, as it were, of more or less prolonged duration; or, the victory of one side or of the other may be complete, and either the infected individual succumb in death, in the one case, or the bacteria be completely routed and driven forth, in the other. We will now briefly consider these three possibilities.

The condition which we have considered as analogous to a "guerilla warfare" is one in which the septic process does not actually subside entirely, but either is continued, in a more mild type, at the original site of infection, or manifests itself in constantly recurring furuncles, abscesses, or other septic processes in the same general neighborhood, or in some cases indeed at more remote points, yet in a manner to be distinguished from pyæmia, both by the mildness of the processes and by their local and regionary distribution; the type of the struggle differs chiefly in degree from that of the severer forms of sepsis described in the preceding section.

The condition which we have described as analogous to a truce is one which has received careful study at the hands of many distinguished bacteriologists, notably by Halban[16] and by Perez.[17] The conclusions of Perez are quite in consonance with the careful experiments of Wauters,[18] who believes, contrary to the commonly received impression, that the bactericidal properties of the lymph glands are relatively small, as compared with those possessed by some other tissues of the body, notably by the red bone marrow. The observations of Perez are likewise in accord with those of the investigators who, with Ehrlich,[19] maintain an essential distinction between the different classes of leucocytes, distinguishing between the "myeloblasts," possessed of marked phagocytic abilities, and the "lymphoblasts," possessing this quality but in very slight degree, if at all. The observations and experiments of Perez lead him to the belief that it is the function of the lymph glands to detain the pathogenic bacteria in their meshes, and there, not annihilate them as do some of the more actively bactericidal tissues, but rather expose them to the peculiar influence of the lymphoblasts, which consists rather in robbing them of their pathogenic qualities than in compassing their entire destruction. An intermission in the conflict between invading bacteria and resisting body cells occurs when the previously active bacteria are temporarily eliminated from the tissues "at large," to be gathered into the emasculating embrace of the lymph glands, from whence, possibly, they may from time to time emerge as unruly prisoners—somewhat shorn, indeed, of their most virulent characteristics—to induce a relapse of an apparently terminated warfare, and manifest themselves often in ways totally different clinically from the first onslaught of the infection; *e.g.*, what first manifested itself as a pyogenic process may, under the influence of the same bacteria, modified by their sojourn in the lymph glands, take on any of the types of non-purulent disturbance which we saw that the pyogenic germs were capable of inciting (*vide supra*), and appear as a neuralgia, as a catarrhal affection of a mucous membrane, or as a serous or sero-fibrinous serositis, of acute or chronic type. Thus, according to the results of the latest experimental research, do the lymph glands afford another form, quite *sui generis*, of protecting agency to the body in its conflict with infecting germs, and if unable to annihilate the invaders completely, conclude with the foe an advantageous armistice, at the close of which the body may resume the conflict under other and presumably more favorable terms.

The third and most decisive outcome of the struggle against infection is the complete destruction of the bacteria and their elimination from the system. This has likewise been long the object of closest observation and most ingenious experiment. Here again the earlier ideas of the excretion of the bacteria themselves by the emunctory organs of the body have had to give place before more recent and more exact studies, and the same is largely true of the elimination of the bacterial toxins. In regard to the elimination of the bacteria themselves, we have the authority of von Klecki,[20] corroborated by that of Cotton,[21] for the statement that though many kinds of bacteria can, indeed, be excreted by the normal bile passages in very small numbers, and probably but not certainly by the normal kidneys also,—this, however, only when they are present in large numbers in the blood, —yet their elimination from the body in this manner, in any considerable number, argues a lesion of the excretory organ in question. "In no wise," says Cotton most positively, "is the commonly received opinion to be accepted that the excretion of bacteria by the emunctories is to be regarded as part of the normal defence system (*Schützvorrichtung*) of the body." Goldberg likewise was unable to demonstrate the excretion of tetanotoxin by the kidneys, and his experiments serve to throw doubt upon the excretion of bacterial toxins, as such, from the body by any of the excretory organs.[22] We must look then for some other way which the body possesses of ridding itself first of the microbes, and secondly of their toxins.

Thanks to the studies of Nuttall,[23] Gamaleía,[24] Denys, Sawtschenko,[25] and Pfeiffer, we are happily in a position to offer a reasonable opinion as to the method by which the system rids itself of bacteria when it has succeeded in extinguishing their vitality. Says Nuttall in regard to the anthrax bacilli: "In the bodies of bedbugs (and of other blood-sucking insects) they become less and less capable of becoming stained with methylene blue and finally altogether so"; "they are simply digested," "*werden einfach verdaut.*" According to Gamaleía, it may now be regarded as settled that the bactericidal substances in the body (*vide supra*, the proteolytic ferments) dissolve the bacteria. To our eyes the process becomes first appreciable as a disappearance of the staining capacity (*i.e.*, a chromatolysis), in a word, a bacteriolysis. A variety of alkaloids, *e.g.*, caffeine, and a variety of ptomaïns, such as methyl- and ethylamin, have chromatolytic properties, as have a number of other bodies—among them, more particularly casein. On further investigation to determine which derivative of casein it is that occasions chromatolysis, it was found that the ammonia salt of glutaminic acid possessed this quality in marked degree. When a fluid in which chromatolysis has taken place is treated with acetic acid and filtered, and the residue on the filter paper dissolved with ammonia, we obtain bacteriolysin, which not only occasions chromatolysis, but totally disintegrates the bacteria, separates the rods (of anthrax bacilli), and causes these to fall to pieces, to form but an amorphous mass of detritus. The thick, opaque emulsion of bacteria changes, under the action of this ferment, in the course of from six to twelve hours into a transparent fluid with scarcely apparent turbidity. From this last solution of bacteria the ferment can again be precipitated by means of acetic acid. The ferment which is obtained by treating anthrax bacilli with glutaminic acid has a bacteriolytic action only upon anthrax bacilli and upon no others. By the action of the casein derivative, or of an amido-acid, upon the cholera vibrio and upon the diphtheria bacillus, corresponding bacteriolysins are developed.

With these data before us, it is possible to understand fairly well how the pathogenic microbes are eliminated from the system. They are, as we have seen, actually dissolved and digested by the tissues, and it is probable that by this peptonizing action of the tissues their proteids are split up, in a manner more or less remotely analogous to the splitting up of proteid molecules in the process of gastro-intestinal digestion, until they are reduced to a chemical condition which permits them to be excreted by the ordinary emunctory channels, in a form more or less indistinguishable from the products of the disintegration of proteid molecules derived from any other indifferent source. It is probable that the liver is largely concerned in rendering the dissolved bacteria fit for excretion, as we know it is influential in rendering innocuous other poisonous products.

As it is only under exceptional conditions that the bacteria themselves are eliminated as such by the kidneys and the other emunctories, so likewise it is only under exceptional conditions that the bacterial toxins are eliminated as such, and in recognizable form, by the emunctory organs. On the contrary, it is recognized, in the first place, that they are in great measure neutralized by the body antitoxins before their elimination (which would in itself account for the non-appearance of specific toxins in the urine, the fæces, and the sweat); and in the second place, it is more than likely that the neutralized toxins are further broken up by the action of the liver, and prepared thereby for elimination eventually by the ordinary emunctory channels in an undifferentiable form, along with the ordinary waste products of metabolism.

Having now considered in some detail first the etiology and then the pathogenesis of dissection and operation wounds, we have dealt as far as is necessary to our purpose with those characteristics of these affections which may be deemed to distinguish them from other septic processes; and it now remains for us to deal, only much less exhaustively, with the questions of their clinical course, their diagnosis, their prognosis, and their treatment, which are to all intents and purposes those of sepsis, from whatever cause arising, and are more fully treated under other headings in this work.

C. Clinical Course.—The clinical course of dissection and operation wounds can best be made plain by the citation of four characteristic and illustrative cases.

Case I. That of Dr. K. Zmigrodzki, of St. Petersburg.[26] The infection in this case was received from a patient who suffered primarily from facial erysipelas. The patient was dismissed from the hospital apparently well on July 7th, 1888, but was received into the hospital again (August 30th?) on account of an extensive phlegmon of the right scapular region. On September 5th, 1888, Dr. Z. made several incisions to void the pus, and packed and drained the wound. The patient recovered quickly, and left the hospital on September 22d.

In performing this operation on September 5th, Dr. Z. acquired, he does not know how, a purulent infection, perhaps through some slight abrasion. Already during the night following the operation he felt severe pain in the left thumb, near the nail, on the ulnar side. On the morning of the 6th, there was a developing panaritium subunguale; on the 7th, he himself injected cocaine and opened the beginning abscess and applied an antiseptic dressing. He did not feel the slightest doubt of a prompt recovery, which, however, did not follow; the wound did not heal but became dry and very sensitive, and occasioned some fever. Under cocaine, a colleague removed part of the nail and made two deeper cuts, but found no pus; an antiseptic dressing was applied.

Healing was now confidently expected, but instead, on September 20th, the patient suddenly had a severe chill, with pain in the left side of the chest along the margin of the ribs. Thinking this to be a colitis, the patient took a dose of castor oil and calomel, but experienced no relief. A careful examination by a colleague on the 23d revealed an affection of the left lung; in the upper lobe, near the linea axillaris anterior, there were dulness on percussion, increased vocal fremitus, pleuritic friction sounds, and a circumscribed patch of subcrepitant râles. The coughing was at first very slight, but on the third day the sputum raised was somewhat bloody, brownish in color, and consisted of lumps of inspissated mucus. After two or three more days, all the other signs of infiltration about this spot in the left lung had disappeared, with the exception of the râles, and the pains in the side ceased; the temperature fell quickly, and the sputa, which had become copious, came to consist of mucus only. From these clinical phenomena there was made a diagnosis of hemorrhagic infarct, of embolic origin, which was deemed to be closely related, etiologically, to the panaritium on the left hand, as this showed not the slightest indication of healing.

Says Dr. Z., who reports the case himself, "I lay especial emphasis on the fact that there was absolutely no appearance of the advance of the inflammation beyond the distal phalanx of the thumb, neither at this time nor during the whole course of my disease; absolutely no lymphangitis, erysipelas, or lymphadenitis, the customary accompaniments of septico-pyæmic infections, was at any time present."

After a few days, a second infarct made its appearance, under strictly analogous circumstances, followed by a third, a fourth, a fifth, and a sixth in the course of the next three or four weeks, and all in the same left lung. The consultants called at this time confirmed the diagnosis of pyæmic infarcts and offered an unfavorable prognosis, *quoad vitam*. The treatment was symptomatic, with special attention to the preservation of the general strength and the maintenance of the heart function. The radial pulse throughout the whole sickness remained strong, though the patient refused alcoholic stimulation.

At this time there developed a circumscribed phlebitis above the inner malleoli of both feet (phlebitis venarum saphenarum interiorarum). This manifested itself as a livid, excessively tender swelling of the skin, which imparted to the examining finger a "doughy" feeling, if not an actual sensation of fluctuation. Under bichloride dressings this quickly subsided, leaving only some pigmentation behind.

"On October 17th, the temperature, which had all along been very high, dropped from 100.4° F. to normal, and, in spite of the dubious prognosis, I began slowly to improve, my appetite returned, and on October 31st, that is, on the forty-second day of my illness (counting from September 20th, the day of the chill), I left my bed. After about a week and a half I went out for the first time, and my strength slowly returned. I still felt constantly dull pains in the spinous processes of the lumbar vertebræ, specially after long-continued sitting; to this, however, I paid but little attention.

"One day, on getting out of a carriage, I felt suddenly a severe pain, like a sprain, in the outer malleolus of the left foot; from that moment on pain, of a rheumatic type, persisted for a long time, extending along the whole of the left lower leg. After a couple of days there developed an evident periosteal swelling on the anterior aspect of the upper third of the left tibia, below the tuberosity, and another over the lower end of the left fibula, on the posterior aspect of the leg. I did not wish to resume my bed, and so kept about, applying hot applications from time to time.

"As I had no attacks of feverishness, I made no observations of the temperature from October 31st till November 10th. On November 11th I was again obliged to resume my bed as the temperature rose with a severe rigor to 103° F., and I felt great pain in the right hypochondrium. Examination now revealed another infarct, this time in the posterior portion of the lower lobe of the right lung; this ran a course similar to that of those in the left lung, accompanied, as were they, by a remittent type of fever. But there developed in this case a fresh complication, namely, a considerable pleuritic exudate in the lower part of the right pleural cavity. The temperature excursus was very great, and was accompanied each time by rigors and profuse sweating. The pleuritic pains were at first very severe.

"In the early part of December I began to feel most torturing pains in the right hypochondrium, which I may describe as diaphragmatic, to check which I was compelled to breathe as superficially as possible, and resorted to the use of hypodermic injections of morphine. From December 1st to 15th the temperature was constantly in the neighborhood of 102° F., and the character of the fever was more or less steady (febris continua); this, of course, greatly reduced my strength. On account of steady pain beneath the right ribs, as well as supervening painful spasms of the abdominal muscles of the right side, especially of the musculus rectus abdominis dexter, I could lie only on my right side, holding the right leg flexed at the hip. From time to time there were rigors and profuse sweating."

All these severe symptoms were scarcely explained by the comparatively unimportant anatomical changes to be found in the lungs and pleura, the only objective symptoms at that time discoverable. Repeated urinalyses failed to show any pathological change in that secretion. The condition had become very grave; all therapeutic effort seemed unavailing.

By December 20th the clinical picture became somewhat simplified, in that a swelling, apparently a perinephritic abscess, appeared in the right lumbar region On December 21st a long lumbar incision was made, under chloroform; this revealed a purulent infiltration not only of the subcutaneous and intermuscular connective tissue, but also of that surrounding the right kidney. Fluctuation was also determined in the kidney itself. The kidney capsule was split and from it was evacuated a large amount of pus. There was present a suppurating embolic infarct of the kidney itself. The wound was irrigated and packed and treated on antiseptic principles. By evening the temperature fell to 97.4° F.; and rose the next day to 101° F.; and from the 22d to the 28th of December there was a wide variation of the temperature, evoked by the formation of a new infarct in the left lung. From December 26th to 28th the temperature fell in forty-eight hours from 104.4° F. to 97.2° F. on the appearance of expectoration, at first bloody, but later purulent. On December 30th the temperature again rose to 101° F., but after that remained normal.

In the beginning of January, 1889, there appeared a recrudescence of the periostitic process which had been observed in October, 1888, on the upper third of the anterior aspect of the left tibia. Severe rheumatic pains asserted themselves throughout the whole of the left lower leg, and presently another swelling, similar to the one above, appeared at the old spot on the lower end of the fibula. The upper spot very quickly suppurated (in spite of vigorous mercurial inunctions) and was opened by an incision under cocaine at the end of three weeks. From the wound was removed a sequestrum of the cortical portion of the bone. On March 5th the lower swelling was opened, under chloroform, and from it also a sequestrum was removed from beneath the periosteum, which membrane was separated by a layer of pus from the underlying bone. "Both wounds healed comparatively soon, and by the end of March I was again out of bed."

"In spite of good diet and hygienic living my strength returned very slowly after a seven months' illness. As a sequela there developed a pronounced anæmia, which was in turn the occasion of a (psychic) neurasthenia, manifested in absolute apathy, indecision, and confusion of ideas; this culminated in a "délire de persécution." May, June, and July, 1889, were passed at the seashore, where loafing, sea-bathing, and walking were helpful, along with the change of air, in restoring a certain degree of strength. Not until June did the wound in the back heal entirely.

"During my sojourn at the seashore, a new periosteal swelling formed on the lower epiphysis of the left tibia. In May, 1890, this suppurated and opened spontaneously, and after healing left a pigmented scar. During all this time the left lower leg was frequently œdematous throughout. A periosteal swelling also formed on the olecranon process of the left ulna.

"Up till the present time (October 2d, 1890), I suffer now and then from cramps in the abdominal muscles of the right side, and from paræsthesiæ in the course of the ileo-hypogastric and ileo-inguinal nerves."

Case II. That of Dr. Roswell Park, of Buffalo, N. Y.[27] Writing under date of February 13th, 1898, Dr. Park says: "For eight months, and until the first of the year, I was completely out of work as the result of an infection. Now, I am happy to report myself as well again, and hard at work. My case has puzzled every one to whom it has been submitted, and no one term or even sentence would define it all. It was certainly a mixed infection, but just when it occurred I do not know. It came on slowly with manifestations mostly confined to the lymphatics of the left arm and axilla; for two months these were troublesome. Then a sudden attack of diaphragmatic pleurisy, with probable mediastinal infection, prostrated me. Then, a few weeks later, I had the lymphatics of the arm all dissected out. I was just getting out after this when acute septic symptoms appeared, and the axillary nodes swelled enormously. I then had the axilla all cleaned out; within two hours my temperature fell 8° F. But there was no pus present either time, and cultures and all sorts of bacteriological studies gave no result. After this I went to the seashore, came back with partial (toxic) laryngeal paralysis, went abroad, was quite sick over there, but finally came home well in every respect, only wearing my scars."

Case III. That of Dr. W. W. Keen, of Philadelphia, Pa., who says, writing on February 11th, 1898: "I made a post-mortem on a case of suppurative peritonitis, following cancer of the stomach, at 11 A.M., on January 9th, 1898. In doing so, I inadvertently and very slightly pricked my right thumb with a needle. The hand was disinfected by washing, but the wound was so slight that it was not deemed necessary to lay it open at once. At six o'clock that evening I began to feel chilly, by nine o'clock I went to bed, as I felt so unwell. It was impossible for me to sleep, because by that time the thumb had become the seat of severe throbbing pain, and in the neighborhood of the prick the tissues were already becoming hard. By 2 A.M., feeling quite sure there was an infection, I called a brother surgeon who laid open the thumb and disinfected it with bichloride of mercury solution, 1 to 500, and applied the same as a dressing. A quarter of a grain of morphine gave some sleep, but by eight o'clock the next morning, about twenty-one hours after the infection, I was vomiting repeatedly, and had a temperature of 105°. Twenty-two grains of quinine and six ounces of whiskey were administered in each twenty-four hours for three days, with sufficient morphine to procure sleep. The pain was very severe. The swelling of the thumb was so great that all the tissues were under great tension, so that it was feared that either necrosis of the last phalanx would take place, or, as a dark spot appeared on the edge of the wound, that possibly gangrene of the tissues might follow. Accordingly, on the third day, the incision already made was enlarged and the parts were disinfected anew. Fortunately the lymphatics were never involved. Within ten days the constitutional symptoms had disappeared, but the thumb did not heal for about six weeks. Two cultures were taken from the incision in my thumb (of course after the primary disinfection), but showed no growth whatsoever, though taken separately on different occasions. Unfortunately no culture was taken from the abdomen of the patient at the time of the post-mortem, so that I do not know what the nature of the infection was. It seems to me that the very prompt incision made by Dr. Taylor, and the thorough disinfection account for the absence of lymphatic involvement, for I never had the slightest tenderness in the axilla; and they also account for the sterile cultures.

Case IV. That of Dr. Charles P. Strong, of Boston, Mass., reported by Dr. Harrington.[29] "Dr. Strong died of acute septicæmia six days after operating upon a patient with septic peritonitis, probably of appendicular origin. The nature of the disease was not determined until after the death of the patient. The point of entrance of the septic poison is not known, as no wound was discovered anywhere upon the body. The circumstantial evidence is so strong that there can be no doubt that the disease resulted from the operation, notwithstanding the fact that all the usual precautions were taken.

"On the day following the operation Dr. Strong performed a hard day's work. He mentioned in the afternoon that the left arm felt somewhat sore, but he did not speak of it again in the evening. He had a somewhat restless night, and decided on the following day not to go out to his work. I saw him then for the first time. He complained of some pain in the left pectoral muscle, left shoulder, and elbow. The temperature was normal and the pulse 80. There were a loss of appetite and some nausea. In the evening the temperature was 100° and the pulse 90. The patient was drowsy through the day, and slept a good deal. There was a trace of albumin in the urine.

"On the following morning the temperature was 102° and the pulse was 90. There was some sweating. In the evening the temperature rose to 103° and the pulse to 98. The urine contained a large amount of albumin. The patient still complained of pains in the left arm and back. There was a disinclination to take food. A moderate amount, however, both of food and stimulants was given. On the following morning the temperature remained at 103° and the pulse at 98. There was still much inclination to sleep. In the afternoon there was complaint of pain in the right knee and right thigh just above the knee. The temperature remained at 103° and the pulse rose to 108. During the night there was considerable pain in the right knee and thigh.

"In the morning there were found to be some fluid in the right knee-joint, and swelling of the lower part of the right thigh. A ham splint was put on and the leg suspended. An examination of the urine showed a large trace of albumin, hyaline, granular, and fatty casts, but no blood. The temperature had fallen to 101°, while the pulse remained at 108. The patient had been perfectly clear in his mind and fairly comfortable. In the evening the temperature had dropped to 100°, but the pulse had risen to 120 and was of bad character. The sweating became profuse. The following night was a comfortable one.

"In the morning the pulse had risen to 128 and the temperature to 101.8°. During the night the thigh had swollen considerably. The heart's action was feeble, and there was a duskiness about the skin. The respiration, which had remained normal during the entire sickness, rose rapidly during the morning to 50 per minute. On examination, bronchial breathing was detected over the upper lobe of the right lung. The patient sank rapidly and died in the evening, this being the fifth day of his sickness. The thigh in a few hours became dark and greatly swollen, and was covered with bullæ.

"The symptoms up to the last twenty-four hours had suggested an attack of la grippe, with the usual acute irritation of the kidneys. The condition of the right knee had suggested an acute inflammatory rheumatism. The marked changes in the thigh did not appear until the last few hours. The treatment had been supporting and stimulating. No depressants had been used. The amount of pain was not great, so that opiates were not needed. The patient did not associate his illness with the operation, which was its probable cause. It was subsequently found on investigation that, at the close of the operation, Dr. Strong had pricked one of the fingers of the left hand with a needle which was being used in closing the incision.

"Several months earlier Dr. Strong had suffered from a synovitis of the left knee, but there had been complete recovery; and no connection could be traced between this and the subsequent illness. There was no evidence of a chronic nephritis.

"*Autopsy.*—The preliminary bacteriological examination and autopsy were made by Drs. Councilman and Whitney, about twelve hours after death, and the bacteriological cultivations were made by Dr. Stone.

"There was lividity of the dependent parts of the body, and the course of the cutaneous veins was marked by dark, dirty bluish-black lines with illy defined edges. The right thigh above the knee was swollen, dark, and discolored, with numerous bullæ containing a dirty-red serum. The lungs contained a large amount of frothy, reddish fluid, but there was no evident consolidation. The muscular substance of the heart and the parenchyma of the liver and kidney were very pale and opaque. The spleen was swollen, pale, and very soft. The other organs presented nothing remarkable. The muscles of the external aspect of the right thigh were dry, infiltrated with blood-coloring matter, but there was no evident pus.

"Cover-glass preparations gave the character of the bacteria as micrococci, chiefly in long chains (streptococci). Cultures were made from the heart's blood, the liver, kidney, spleen, and subcutaneous tissue of the thigh. From all of these there was obtained a pure culture of streptococci. These grew in long chains in bouillon and on agar. In the former they made the fluid cloudy for twenty-four hours, and then settled as a white precipitate. In gelatin they grew along the needle track in small isolated colonies. They grew also in milk but did not coagulate it. On blood serum the bacteria formed small white colonies, at first almost like drops of water on the surface. They developed rapidly in the thermostat at 37° C., more slowly at the ordinary temperature of the room.

"The sections of the muscles of the thigh showed that all the intermuscular spaces were distended by a mass of bacteria, there was no infiltration of leucocytes into the tissues, though the blood-vessels seemed to contain an unusually large number of white blood corpuscles. In sections of the kidney the bacteria were demonstrated with considerable difficulty, in spite of the fact that the amount of kidney substance one could pick up with a small wire loop gave over one hundred colonies when planted. When found, the cocci were in the intercellular spaces. Neither in the kidney nor in the muscular tissue was there any suggestion of arrangement of the cocci in chains. This was to be seen only when they were cultivated outside of the body.

"The case is one of true septicæmia following a local streptococcus infection, the original point of infection not being evident."

D. Diagnosis.—The diagnosis of dissection and operation wounds is essentially that of the sepsis which accompanies them. When this has a distinct local expression, at the site of inoculation, as in Cases I. and III. the diagnosis is not specially difficult; but when the portal of infection is concealed, as in Cases II. and IV., the diagnosis presents difficulties which may even become extreme. A pure infection with pyogenic germs may, as we have seen, find expression in a great variety of morbid processes, and consequently sepsis, as a disease, may counterfeit a whole host of other more familiar morbid conditions; among others grippe, typhoid fever, malaria, rheumatism, and scarlet fever, and the specific pneumonias are those perhaps most likely to confuse the diagnosis for a time, or even till the end of a fatal case. On this account the history of recent exposure to septic infection, in a physician or a pathologist, should always be allowed weight in the diagnosis of any of these affections occurring in professional men. Two means of differentiation are available to us in doubful cases: first, an examination of the blood for the determination of leucocytosis, and, secondly, a bacteriological examination of the blood itself. The first of these is quite easy of application, and is capable of giving most important information in any case in which the system offers any considerable resistance to the invasion of the pyogenic germs.[30] The two conditions in which it may fail to afford a clew to the proper diagnosis are, first, when the infection is so slight as not to evoke any considerable reaction on the part of the tissues, and secondly, when the invasion of the system is such an overwhelming one that all its efforts to react are borne down, practically without a struggle, and the patient perishes forthwith of "septicémie foudroyante." The careful bacteriological examination of the blood is a more considerable matter, the technique of which does not properly concern us here, beyond the remark that it requires for its accurate performance quite a considerable quantity of blood (an ounce or more), and that negative results from the examination of smaller quantities should not be allowed much weight. The actual discovery of pyogenic cocci in the blood is of most grave prognostic import, and is gravest of all in the presence of streptococci. As it will be remembered that true septicæmias, *strictiori sensu*, are by no means as common in man as in the lower animals inoculated with the bacteria to which they are specifically susceptible, the appearance of even a small number of germs in the circulating blood implies a most profound, extensive, and dangerous condition of general sepsis. A single word may be said in regard to the discovery, in blood specimens gathered by aspiration through the skin, of the Staphylococcus pyogenes albus; this coccus, which Welch has named the Staphylococcus epidermidis albus, has been shown by him to have its habitat in the skin in layers deeper than can be reached by any known means of disinfection. The discovery, therefore, of this germ alone in blood cultures has not the grave prognostic import which attends the appearance of the Staphylococcus aureus or that of the Streptococcus pyogenes.

E. Treatment.—It will be our duty in this connection to consider principally the treatment of the primary local lesion and its direct and immediate sequelæ, the treatment of an ensuing pyæmia, septicæmia, or pyo-septicæmia being more fully discussed in other parts of this work. For the formulation of a rational treatment for these forms of septic infection we are considerably indebted to E. H. Ochsner, of Chicago, from whose valuable article I shall quote freely.[31]

If the infection has come from a pin prick or similar wound through a thick and calloused layer of the skin, it is advisable carefully to shave away the horny layer at the point of infection till one gets down to the quick, but one should avoid cutting into the healthy tissue. If now a little pus should form at the point, it will work its way to the surface and discharge spontaneously, or it can be released as soon as there is macroscopical evidence of pus.

If ever so slight a wound be received upon the hands during the performance of a surgical operation or of an autopsy upon a subject with puerperal fever, pyæmia, septicæmia, a carbuncle in its acute stage, malignant erysipelas, phlegmonous cellulitis, or suppurative peritonitis, it is worthy of the gravest consideration and of the most scrupulous care on the part of the surgeon. This suggestion of Dr. Ochsner, viz., that of shaving off the superficial epidermic layers, is very valuable, but this should be followed by active measures for disinfection. One of the most effective of these measures is the immediate application of a drop of ninety-five-per-cent. carbolic acid; indeed, the investigations of Seneca D. Powell have taught us that so efficacious is the antidotal effect of alcohol in removing the excessive destructive effects of carbolic acid that the hands can be washed with impunity in ninety-five-per-cent. acid, if alcohol is at hand in which to bathe them afterward. If carbolic acid is not at hand, glacial acetic acid is a very valuable application, or any strong acid whatsoever; one means will always be at hand during a surgical operation, namely, the disinfectants by which the hands were disinfected in the first instance, *e.g.*, oxalic acid and permanganate of potassium or chloride of lime and sodic carbonate, or at least bichloride of mercury solution, and the resterilization of the hands with these should be resorted to without delay, the operation even being interrupted, if necessary, for the purpose.

It is well to repeat, for the sake of emphasis, that on the receipt of the most trifling scratch during the performance of an operation or of a post-mortem section, in the presence of any of the diseases enumerated above, some one of the means suggested should be applied without delay. If it should be absolutely necessary for the surgeon to continue the operation himself, he should recognize the fact that he resumes his duty with considerable risk, and that every effort should be made to protect the tiny wound from further contamination, by the use of a finger cot, of a collodium film, or, at the very least, of a small gauze dressing.

The homely but simple recommendation to suck the wound vigorously has much to recommend it; not so much with the view, in which it was originally recommended, of "drawing out the poison," but rather because vigorous sucking occasions mechanically a certain amount of diapedesis of the blood corpuscles from the vessels, and creates artificially a chemotaxis whose default, as we have seen above, was a factor of some moment in allowing the insidious development of bacteria in cases of inoculation with but slight trauma. Similarly the constriction of the base of the finger occasions an engorgement of the part with blood, and a diapedesis of the blood corpuscles—a measure which has been recommended for use in the treatment of tuberculous joint lesions. Of the two, it would seem likely that vigorous sucking of the wound would be the simpler and at the same time probably the more efficacious.

In discussing the treatment of the kind of infections we are considering, Ochsner groups his cases under four heads:

Class I., that form of infection which betrays itself by a marked local disturbance with the formation of pus at the point of infection, the systemic disturbance being relatively slight.

Class II., that form in which there is marked local disturbance with the formation of pus at the point of infection and with an ascending cellulitis, the systemic disturbance being usually more marked than in Class I.

Class III., that variety in which there is only slight disturbance locally, but in which there is an early and severe involvement of the regional lymphatic glands and severe general disturbance.

Class IV., that form in which there is no demonstrable local disturbance and only relatively little disturbance in the regional lymph glands, but in which there is severe general intoxication due to the presence of the pathogenic bacteria or their ptomaïns in the blood.

In the first two classes the indications are plain and the treatment is relatively simple: elevation of the extremity at the very onset, copious wet dressings; free incision and free drainage, just as soon as there is macroscopical evidence of pus. It is well in these cases carefully to apply an Esmarch constrictor to the limb, proximal to the inflamed area, before the incision is made. It is claimed, and, says Dr. Ochsner, "I believe correctly," that the danger of disseminating the infection is greatly reduced if this precaution is observed; the theory being that, while the incisions are being made, it is best to compress the lymphatics and veins, thus closing them until thrombi have formed in their cut ends, so as to prevent particles of infected material being taken up by either of these systems and disseminated through the body, thus furnishing foci for pyæmic abscesses, septic endocarditis, or septicæmia. (See also in this connection the observations of Billroth[32] on the provocation of chills in pyæmia, by dressing the wound.) One other caution Dr. Ochsner emphasizes, namely this, that the incision (or incisions) should be made wholly within the infected area; that is, they should not pass beyond the line of demarcation, if such exists, as is usually the case, to a certain extent at least. By following these rules the pus can be evacuated with safety without opening up new areas to infection, and the danger from the above-mentioned complications or sequelæ is reduced to a minimum.

In considering the treatment of the third class of cases, those in which there is only slight disturbance locally, but an early and severe involvement of the regional lymph glands and quite marked systemic disturbance, Dr. Ochsner remarks that while in Europe he noticed that surgeons and pathologists differed very markedly in their treatment of this class of infections acquired during surgical operations or necropsies. Most of the surgeons seemed to favor early and free incisions, while the pathologists had learned better. They are infected so frequently that they have learned to treat themselves much more satisfactorily than even the surgeon could. He quotes a conversation which brings out this point forcibly: One day one of the surgical assistants came to the pathological laboratory with his arm in a dressing, suffused eyes, pyrexia, and considerable systemic disturbance. The director of the laboratory, Dr. E. Fraenkel, of Hamburg, stepped up to him, asked him what had happened, and, after being told that he had an infected finger with enlargement of the lymph glands in the elbow and axilla, as well as a slight lymphangitis, said about the following: "Now do not let the surgeons get at you; go to bed, put on a copious wet dressing and you will be well in a few days, while if you let them lance it, you may be laid up for weeks; at best you will not be able to resume your work for some days if you have a gash in your finger."

The sick assistant very wisely followed the advice and was back at his work in less than a week. This he certainly could not have done with safety to himself or justice to his patients if he had an infected knife wound in his finger, as he surely would have had if he had permitted it to be lanced.

Dr. Ochsner thus briefly outlines the treatment which he has used in a large number of cases: "I insist upon rest in bed, elevation of the infected extremity, free evacuation of the bowels by means of calomel and saline cathartics, not purging, simply free evacuation, that is, three or four bowel movements the first day, plenty of good pure water, preferably presented at regular intervals so that the kidneys are able properly to perform their function. It is quite noticeable how much better patients do in hospitals as well as in private practice if they are given a definite quantity at definite intervals. They suffer less from headache, pyrexia, and gastro-intestinal disturbances. To continue, I insist further on liquid diet, avoidance of constriction to the lymphatic channels and blood-vessels, avoidance of pressure upon the lymph glands, and, finally, copious wet dressings. The dressings must be copious in order to be effective. It is in the way of putting on too small a wet dressing that many general practitioners and even surgeons often err."

"I experimented," he says, "for some time to determine the best form of wet dressing for these as well as other purposes, trying to find out the best combination, both as to efficiency and comfort to the patient, and my final result is the following:

Boric acid, sat. sol.	6 parts.
Carbolic acid, 5-per-cent. sol.	1 part.
Alcohol, 95-per-cent	1 "

The solution should be applied hot.

"This formula may sometimes be modified with advantage. If the part is not painful I often leave out the carbolic acid entirely. Again, some patients do better if the proportion of alcohol is increased. The boric acid is put in because of its well-known germicidal effect; the carbolic acid, because of its anæsthetic effect; the alcohol, because of its action as a germicide, and that it keeps the whole limb warm and comfortable. I use the plain sterile gauze for dressing by preference, because I believe it to be more effective and certainly more comfortable than cotton."

Should softening of the affected lymph glands take place, a sequel which very rarely occurs if the dressings have been properly and conscientiously applied from the very onset, they should be freely incised and drained with a gauze (or a rubber?) drain, but should not be enucleated, as whatever can be left may some day act as a barrier against general infection. (N. B. This last recommendation of Dr. Ochsner's appears to me to be one of questionable wisdom; see the case of Dr. Park detailed above.)

The following are the theoretical reasons for believing that the conservative treatment just outlined is more rational than early free incision: The infective agent is usually introduced in minute quantities, it is virulent, and is rapidly carried to the nearest lymph glands. Contrary to the contention of even very good surgeons, I am of the belief that the original point of infection soon ceases to play an important rôle in the progress of the disease. If it is just left alone, the inflammatory reaction at this point, if it has not all subsided, will do so in a very short time. The leucocytes are rapidly getting the upper hand. The conditions become entirely changed, however, if the already injured part is now subjected to a new traumatism, as a cut, for instance. Now the bacteria are again given a chance. The tissues, which are full of militant leucocytes, are killed, so to speak, by the incising knife, and they then furnish an excellent culture medium for the bacteria which may not have been destroyed; the result being a rather profusely secreting, unwholesome-looking, slowly healing ulcer.

In the fourth class of cases, those where there is practically no reaction at the point of infection, or where this may be undiscoverable; where there may or may not be involvement of the regional lymph glands, and where the general septic intoxication is severe, Dr. Ochsner recommends practically the same course of treatment as in class three just discussed.

He says, most properly, that even the most aggressive surgeons have given up incising the point of infection if there is no inflammatory reaction at all; but he opposes the practice of some who "still persist in taking out the involved lymph glands." The fortunate issue of Dr. Park's case, just alluded to and described above, would indicate that the removal of the affected lymph glands is in proper cases good, and, it is not too much to say, the only good practice.

Recent advances in bacteriology would indicate that in this fourth class of cases, whose prognosis is always grave and often desperate, another means, not distinctly surgical, may be available for combating the bacteria which are causing the profound sepsis which threatens the life of the patient, namely, the introduction into the system of specific remedies calculated to destroy the bacteria and to neutralize their toxins. Experiment has seemed to indicate that nucleinic acid and some of its derivatives and analogues have in a measure both of these properties, that of inhibiting the development of the bacteria, and that of neutralizing their toxins. A proprietary remedy, claiming to present these substances in available form, has been placed on the market under the trade name of "protonuclein"; whether this particular substance, which is recommended both for hypodermic use and for administration "per os," would be valuable in the treatment of these cases may or may not prove to be so, but it is not unreasonable, in the light of modern investigations, to suppose that some chemical body of that order could be supplied to the system, by the mouth or through the skin, which should greatly aid the system laboring under an overwhelming dose of septic poison, and in just so much rendered incapable of manufacturing for itself a supply of defensive proteids, sufficient for its pressing needs.

Certain favorable reports, furthermore, come to us in regard to the general use (in distinction from their local use) of certain silver salts, by inunction, in a manner similar to the use of mercurial inunctions in syphilis. In some cases of general sepsis, presumably of a streptococcic type (puerperal fever), half an ounce, or even an ounce of Credé's ointment rubbed into the flanks or the belly twice a day has appeared to influence very favorably the course of the disease.

The attempt to eliminate the bacteria themselves, or even their toxins, by means of the emunctories, as we have seen above, is very unlikely to amount to much, and powerful cathartics, diuretics, and sudorifics are more likely to prove harmful than beneficial.

One further resource, however, holds out the brightest promise as a successful means of combating the difficulties in question, and its realization seems almost if not quite within our grasp; I refer to the injection of the serum of immunized animals. The uncertainty of the results obtained by Marmorek's antistreptococcic serum seems in a fair way to be rectified since the studies of Van de Velde have thrown more light on the probable reason for its occasional inefficacy in cases apparently well suited for its employ. Van de Velde, namely, has tried to determine by experiment[33] whether a serum produced by means of a given variety of streptococcus is efficacious against all other varieties of streptococcus pathogenic for man, or whether it is active only against a certain number of varieties. To decide this question he makes use of a serum produced by means of a streptococcus A, and he inoculates a horse with another variety of streptococcus, P, which coccus is chosen because, *in vitro*, its development is not inhibited by the serum A added to the leucocytes of a rabbit; from the horse he acquires another variety of antistreptococcus serum, serum P. Now he observes that serum A is very active when injected in doses of 5 c.c.; it annihilates the effects of five thousand pathogenic doses of streptococcus A, but is able to neutralize the effects of only one hundred doses of streptococcus P. On the other hand, the serum P is able to neutralize the effects of five thousand pathogenic doses of streptococcus P, but is completely inactive against streptococcus A.

These researches, conducted at the Bacteriological Institute of the University of Louvain, have led them, at that institution, to modify the technique of the vaccination of horses for the production of serum, and their immunizations are now made with a mixture of streptococci coming from as many different sources as possible. The serum thus prepared has received the name of "polyvalent serum," and it is anticipated that a serum thus prepared will be more generally and uniformly successful in practice than the antistreptococcic serum prepared in the usual manner.

In the presence of probable, if not indubitable, streptococcic infection of a grave type, especially in cases in which streptococci have been demonstrated in the blood, the question of the administration of large doses of a reliable antistreptococcic serum merits, to say the least, the careful consideration of the attending practitioner.

Zmigrodski, whose distressing personal experience with an operation wound has been detailed above, heads his report of his own case with a pertinent quotation from Dr. Parkes[34]; it will not be unfitting to repeat it here:

"I believe these cases of severe septic infection, if they do get well, scarcely ever do so because of the doctor, but by the grace of God." *Leonard W. Bacon, Jr.*

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DISTOMA. See *Trematodes.*

DITA.—The bark of *Alstonia scholaris* (L.) R. Br. (fam. *Apocynaceæ*), a large tree of Southeastern Asia and the adjacent islands, especially the Philippines, yielding a valuable fine-grained timber. The bark and its alkaloid have been much used at home, and to some extent in this country, as an antiperiodic substitute for quinine. It is a very rough, coarse bark, occurring in pieces as large as the hand and larger, and a fourth to a half inch or more in thickness. The outer surface is coarsely fissured and of a dark-gray or brownish color, the inner is buff and coarsely striate. The texture is largely cellular and it is easily ground or powdered. It is odorless but very bitter.

Numerous crystalline principles have been extracted from it, among them several alkaloids. *Ditaine* (or echitamine, $C_{22}H_{28}N_2O_4$) is the most important. It occurs in brightly shining, prismatic crystals, soluble in both water and alcohol. It is said to act like curare, but its use appears to have been purely experimental. Other alkaloids are *ditamine* ($C_{16}H_{19}NO_2$) and *echitenine* ($C_{20}H_{27}NO_4$). "Ditain," as said to be used in the Philippines in equal doses with quinine, is a very indefinite substance. It certainly is very different from the poisonous bases noticed above.

Dita has not been found of much value as an antiperiodic; it is useful, however, as a general tonic. It appears to be a rather powerful abdominal stimulant, of value in severe diarrhœa. The dose of the powdered bark is 0.2 to 0.5 gm. (gr. iij.–viij.) or as many minims of the fluid extract.

The similar bark of *A. constricta* F. von Mueller, of Australia, has there a similar repute as an antiperiodic.

Henry H. Rusby.

DI-THIO-CALCIUM CARBONATE ($CaCS_2O$) is calcium carbonate in which two atoms of oxygen have been replaced by sulphur. It is a hygroscopic, orange-red, crystalline powder, slightly soluble in water and less so in alcohol. On exposure to light and air its aqueous solution is decomposed, with liberation of sulphur and sulphureted hydrogen. On account of its large proportion of sulphur it was used by Tommasoli and Vicini in five-per-cent. ointment or freshly prepared solution as an application in psoriasis, lupus, eczema, and other skin diseases. Sabbatini has found that a one-per-cent. solution prevents the growth of pyogenic bacteria, but does not kill them. A twenty-per-cent. solution caused a vesicular and pustular dermatitis. *W. A. Bastedo.*

DITTANY.—American Dittany. The herb of *Cunila origanoides* (L.) Britton (fam. *Labiatæ*). This aromatic perennial, found abundantly in rich woodlands of the Eastern United States, is a more energetic carminative than many of its relatives which are more frequently employed. It has a biting, peppery, aromatic taste and contains an abundance of volatile oil. This oil is distilled for the market and appears to be very similar to oil of thyme. The drug and the oil are more stimulant to the perspiratory glands than are most of the aromatics. The dose of the dried herb is 1 to 4 gm. (gr. xv. to lx.).

Henry H. Rusby.

DIURETICS are medicines which increase the secretion of urine. They are divided into two classes, *direct* and *indirect.*

To the first class belong all medicines that produce an increase of diuresis by influencing the kidneys directly; to the second, those that accomplish this by augmenting the general blood pressure.

In order to have a clear conception of the practical bearing of this division, it is necessary to understand the conditions that modify the urinary secretion in health and disease.

The activity of the kidneys, in their healthy state, depends upon the quantity of blood flowing through the renal vessels, and the amount of urinable substances (that is, substances that are eliminated by the kidneys, such as water, inorganic salts, urea, uric acid, etc.) which it contains. As both the quantity and quality of the renal blood undergo marked changes, the urine secreted at different times by healthy persons presents striking variations in amount, color, and density. These variations are readily accounted for by the fact that the principal constituents of the urine, the water and the solids, are secreted in different parts of the kidneys—the Malpighian bodies and the uriniferous tubules. These two parts are not always equally active, and hence the normal variations in the composition and quantity of the urine.

The quantity of the water of the urine depends chiefly on the activity of the Malpighian bodies or glomeruli. They separate from the renal blood its surplus of water and those salts which it normally holds in solution, such as chloride of sodium, etc. From the glomeruli the water passes into the lumen of the uriniferous tubules, where it serves as a solvent or vehicle for any substance that may have been secreted by the epithelial cells of the tubules. The quantity of water yielded by the glomeruli is regulated, according to Ludwig, by the pressure of the blood in the capillaries of the glomeruli, but according to Heidenhain, by the velocity of the blood current. Ludwig holds that the passage of water through the walls of the capillaries and the simple layer of epithelial cells covering the tuft of capillaries, is merely a mechanical filtration. Accordingly, the greater the pressure in the capillaries, the more abundant the water that filters through them, and the more the pressure in the glomeruli exceeds the pressure in the tubules, the more rapid and extensive the process of filtration. Heidenhain, on the contrary, maintains that it is the velocity of the blood current that determines the quantity of water flowing from the glomeruli. The more rapid the blood current in the glomerular capillaries, the more copious the flow of water. When the blood current is very rapid, a larger quantity of water is brought into relation with the epithelial cells of the glomeruli in a given time, and hence their activity becomes augmented. Thus Heidenhain regards the removal of water from the blood of the glomerular capillaries to be a process of active secretion by the epithelial cells of the glomeruli.

Normally, blood pressure and rapidity of blood flow in the Malpighian bodies are simultaneously increased or diminished, but in some pathological states the pressure may be augmented while the flow is retarded.

As the quantity of water flowing from the glomeruli depends upon the abundance of blood in their capillaries, it is evident that the quantity of urine secreted must be controlled by the general arterial blood pressure. When the blood pressure is high, the urinary secretion is abundant; when it is low, the secretion is scanty. In the normal state of the organism the general blood pressure is such as to supply the kidneys with an abundance of blood, so that they can rapidly remove from it the urinable substances it may contain. Some of the ordinary changes in the quantity of urine are attributable to variations of the general blood pressure. Thus, when the surface of the body becomes cold the vessels of the skin contract, and the general blood pressure slightly increases; the urine then becomes more abundant, less dense, and light-colored On the contrary, when the surface of the body is exposed to a very warm atmosphere, the superficial vessels dilate, and the blood pressure falls somewhat; as a consequence the urine becomes scanty, dense, and high-colored.

But the quantity of water flowing from the glomeruli depends also upon the concentration of the renal blood. When the renal blood contains a minimum of water, the glomerular epithelium can remove or secrete but little, and the urine becomes dense, scanty, and high-colored. On the contrary, when the renal blood contains a maximum of water, the renal epithelium removes the surplus rapidly, and the urine becomes copious and light-colored. This is well illustrated in health by the variations in the quantity of urine resulting from the amount of fluid ingested. Soon after imbibing large draughts of water, a copious flow of light-colored urine takes place.

The indirect diuretics have been defined as medicines that increase diuresis by augmenting the general arterial blood pressure. This results from their action on the heart, whose energy becomes increased. They do not, it is now held by most authorities, exert any direct action on the kidneys, since they are incapable of augmenting the flow of urine when they fail to increase the force of the heart's action. In the normal state of the organism, they do not markedly augment the quantity of urine, evidently because the blood pressure is generally at its maximum height. But when the blood pressure is abnormally low from inefficient heart action, and the secretion of urine has abated in consequence of scanty supply of arterial blood, they display great power over the secretion of urine, often in a short time producing a copious flow.

The quantity of the solids of the urine depends upon the activity of the epithelial cells of the uriniferous tubules. All authors accord to these cells an active secretory function. They take from the blood in the capillaries surrounding the tubules the urea, uric acid, kreatinin, and other products of metabolism, and probably foreign substances such as medicines and poisons, and discharge them into the channels of the tubules. The activity of the epithelium depends upon the quantity of such urinable substances contained in the renal blood, increasing when they are abundant and diminishing when they are scanty. It depends also upon the velocity of the blood current, since with an accelerated flow a larger quantity of urinable substances is brought into relation with them in a given time. When the blood flowing into the kidneys contains a large amount of such substances and a minimum of water, the urine becomes dense, scanty, and high-colored. On the contrary, when the renal blood contains only a minimum of them and a maximum of water, the urine becomes pale, less dense, and very copious. It is evident, therefore, that the degree of activity of the two secreting structures of the kidney is dependent primarily on the quality of the renal blood.

The kidneys, like all other organs, in a measure regulate their own blood flow. When they are active, they contain an abundance of blood; when inactive, they are comparatively bloodless. When, for instance, the activity of the epithelium becomes excited by the presence of urinable substances, there quickly takes place a more abundant flow of blood to the kidneys, or rather to the secreting apparatus, in consequence of dilatation of the renal arterioles. This statement does not rest merely on general principles. Heidenhain found, as a result of his experiments, that a very dilute solution of nitrate of sodium, or urea, injected into the blood, greatly increased the flow of urine, when it had abated in consequence of low blood pressure. No change of the blood pressure resulted from the injections, and hence the augmented flow of urine could not be attributed to rise of the general arterial pressure. That it was solely due to an increase of the local pressure in the vessels of the kidneys, and augmented velocity of the blood current, is evident from the experiments of Cohnheim and Roy. These investigators found that small quantities of a very dilute solution of urea, or of chloride of sodium, injected into the circulation, which in no wise influenced the general blood pressure, soon caused a very decided increase of the bulk of the kidney. This shows that the amount of blood flowing through the kidneys—that is, the degree of dilatation of the renal arterioles—depends upon the quantity of urinable substances in the renal blood and the activity of the renal epithelium. Augmented activity of the epithelium is hence always attended by an active physiological hyperæmia.

From this it follows that all medicines which increase the flow of urine by a direct action on the kidneys cause more or less active hyperæmia. Some of the direct diuretics, if given in large doses, diminish the quantity of urine and render it bloody and albuminous, which shows that they may so greatly irritate the secreting epithelium and the walls of the capillaries as to produce inflammation, and thus retard and even completely arrest the blood flow of many parts of the kidney.

DIRECT DIURETICS.—Some of the direct diuretics produce a change in the chemical reaction of the urine, rendering it less acid or even alkaline. They are called *saline diuretics.* Numerous diuretics, when administered in excessive doses, diminish the quantity of urine, and cause other symptoms characteristic of irritation or inflammation of the kidneys. Hence they are distinguished as *irritant* or *stimulant diuretics.*

Saline Diuretics.—To this group belong many of the salts of potassium, sodium, lithium, calcium, and magnesium. The salts of potassium cause a more decided increase of the urinary secretion than the other salts, and hence are always preferred when an increase of the quantity of urine is indicated.

Of the salts of potassium the acetate, citrate, and bitartrate seem to possess equal diuretic power. This is readily explained by the fact that in the organism they are all converted into the carbonate, and as such are eliminated by the kidneys.

Doubtless, in being eliminated, they excite the renal epithelium to increased activity, in consequence of which an active hyperæmia results, and hence an augmented flow of watery urine. That the increase of diuresis is not due to an augmentation of the general blood pressure is proved by the fact that injections of dilute solutions of chloride of sodium into the veins are rapidly followed by an increase of the bulk of the kidneys and a free flow of urine, although the general blood pressure is not altered. The action of salines is held by many physicians to be due in part to changes of the general circulation, and, in febrile diseases, to lowering of temperature. If they are capable, as claimed by some recent writers, of producing antipyretic effects, their diuretic action in fevers may partly result indirectly. For it has been found experimentally by Mendelson that in fevers the kidneys become diminished in bulk, in all probability in consequence of the action of the hot blood on the vaso-motor centres. Husemann recommends nitrate of potassium, even in small doses, in inflammatory diseases, on the ground that it lowers the febrile temperature and improves the general condition of the patient.

Indications for the Use of Saline Diuretics. The saline diuretics are employed to meet two indications: first, to remove morbid accumulations of serum; secondly, to neutralize an excess of acid in the urine.

Excessive accumulations of serum occur in a variety of pathological states, diseases of the heart, liver, kidney, and as a consequence of inflammations. When the morbid condition giving rise to the dropsy is amenable to treatment, the diuretic action of the salines is often followed by rapid absorption of the effused liquid. This is especially the case when an abundant effusion occurs in consequence of inflammation of serous membranes, as in pleuritis, pericarditis, peritonitis, etc. After the symptoms of active inflammation have subsided, the use of salines is generally followed by rapid absorption.

Their utility is less evident in dropsies dependent upon organic diseases of the heart, lungs, liver, and kidneys; but when associated with other therapeutic means indicated by the pathological condition giving rise to the dropsy, they often greatly hasten absorption. Thus, in cardiac dropsy the chief indication is an increase of the arterial blood pressure. This the saline diuretics cannot accomplish. But when they are combined with the indirect diuretics, which augment the force of the heart's action, they promote the diuretic action of the latter and thus accelerate absorption.

In renal dropsy saline diuretics may be useful or harmful, according to the condition of the kidneys. In the dropsy attending acute nephritis, they will do harm as long as the inflammation is the cause of the diminished secretion of urine. The kidneys, when inflamed, like all other organs, require rest. The administration of salines may not only cause injury to the kidneys directly by augmenting the quantity of blood in them, but may hasten the appearance of uræmic symptoms. When, however, the inflammation has subsided, and the free flow of urine is prevented by the presence of tube casts and masses of blood in the uriniferous tubules, they may become useful by hastening the removal of these impediments.

In the dropsy of chronic renal disease the saline diuretics rarely possess much utility. But in some cases their administration is followed by increased diuresis. This is observed especially when the dropsy results from failure of the compensatory action of the heart. Combined with digitalis, or other medicines that augment the force of the heart's action, they often cause a copious flow of urine. So, too, in the hydræmic dropsy following exposure to cold, or disorder of digestion, the saline diuretics, associated with such remedies as the special pathological condition indicates, are often followed by efficient action of the kidneys.

In any case of chronic renal dropsy the use of saline diuretics, if they do not produce an increase of diuresis, should not be long continued; for if the kidneys have become so severely damaged that they cannot remove the surplus of water from the renal blood, they will also be unable to eliminate these medicines. Their persistent employment will, therefore, soon be productive of serious disorder, especially feebleness of the heart's action and symptoms of uræmia.

For the purpose of increasing diuresis, the acetate, citrate, bitartrate, and nitrate of potassium are given in doses of gr. x. to xxx. every two or three hours.

The acetate and citrate may be administered in several tablespoonfuls of water, to which may be added a small amount of orange or lemon syrup. The nitrate, if given in large doses, should be administered in more water, say a wineglassful, lest it act injuriously on the gastric mucous membrane. On account of its slight solubility the bitartrate also requires a large amount of water.

To meet the second indication for the use of saline diuretics, namely, to neutralize excessive acidity of the urine, and thus to prevent the irritation resulting from excess of uric acid and its deposition in the urinary passages, the salts of potassium are generally preferred, especially the acetate and the citrate. This preference depends upon the fact that the urate of potassium formed under these circumstances is a very soluble salt. Should it, however, be necessary to employ remedies for a long time, and evidences of gastric disorder become manifest, the salts of sodium would be more eligible, as they are better borne by the stomach.

Recently the salts of lithium, especially the carbonate and citrate, have been much used to prevent deposits of uric acid and urates in the urine. Experimentally it has been found that they are more powerful solvents of uric acid than the salts of potassium and sodium. They seem also to dissolve, to some extent, the deposits of urate of sodium occurring in gouty subjects.

The carbonate of lithium is given in doses of gr. iij. to x., in a tumbler of water, several times daily. It may be ordered as follows: ℞ Lithii carbonatis, ℈ij.; sacchari albi, ℈iv. M. Div. in partes æquales No. viij. Sig.: One powder three times a day. The citrate of lithium is preferable to the carbonate, and may be given in doses of gr. v. to x., in a tablespoonful of sweetened water, three times a day.

Caffeina.—This alkaloid acts as a decided diuretic in some forms of dropsy, especially those resulting from cardiac disease. For some years it has been freely employed by French and German physicians in cardiac dropsy, when digitalis had failed. It has been strongly recommended by Gubler, Dujardin-Beaumetz, Riegel, and Binz. According to these observers it regulates the heart's action, slows the pulse, and augments the arterial blood pressure. It produces these effects more rapidly than digitalis, has no cumulative action, and is usually well borne. Often it succeeds after digitalis has been used in vain.

Caffeine is indicated in cardiac and hydræmic dropsy, especially when the heart is fatty.

The citrate or hydrobromate may be given in doses of gr. ij. every three hours, or from gr. v. to xx., in divided portions, in twenty-four hours. The following formulæ are recommended by Riegel: ℞ Caffeinæ citratæ, gr. iv.; sodii salicylatis, gr. iiiss.; aquæ, ℥i. M. For one dose, internally. ℞ Caffeinæ citratæ, gr. xx.; sodii salicylatis, gr. xviiss.; aquæ, ʒi. M. Dose, from ♏i. to vi., subcutaneously.

Adonis vernalis.—This plant, long used in Russia as a popular remedy for dropsy, was recommended by Bubnoff in 1879, and again in 1882, as a succedaneum of digitalis. He carefully investigated its action and uses, and found it to produce the following effects in cardiac disease with dropsy: the heart's impulse became decidedly stronger; its dimensions were markedly lessened; the heart sounds and murmurs, especially the præsystolic and systolic murmur of aortic stenosis, became better defined; the rhythm was rendered more regular and mostly slower; and the pulse was correspondingly influenced, becoming slower, stronger, and fuller. The flow of urine was decidedly increased, sometimes, in the course of twenty-four hours, from ten to eighty or one hundred ounces. Its diuretic action was equally marked when cardiac failure occurred in chronic kidney disease, but only when the dropsy resulted from the weak heart action.

Nothnagel tried adonis in cardiac dropsy, and generally found it to increase the general blood pressure and the flow of urine, sometimes acting after digitalis had failed. More frequently the reverse was the case, adonis failing and digitalis succeeding.

The action of adonis on the heart is due to a glucoside, *adonidin*, isolated by Cervello in 1882.

Adonis has no cumulative action, but it often causes nausea, vomiting, and diarrhœa.

Bubnoff usually gave an infusion containing from ʒi. to ij., of adonis in six ounces, in doses of a tablespoonful every two hours.

Convallaria majalis.—This drug contains a glucoside, convallamarin, which was found by Marmé to act on the heart like digitalin. Both convallaria and its active principle have been tried in cardiac dropsy, with varying results. Thus Leubuscher, who administered as much as 1 gm. of the active principle in twenty-four hours, in no instance observed an increased flow of urine, a fall of the œdema, or a rise of the blood pressure. Hiller also reported unfavorably. Maragliano, on the contrary, found convallaria and its active principle useful in mitral disease with cardiac failure, the heart's action becoming stronger and more regular, and the urine increased. It had no cumulative effect. Frederick Roberts also succeeded with convallaria. In a case of mitral obstruction the heart's action became more regular and efficient, the thrill and murmur more evident, the quantity of urine progressively increased, and the dropsy disappeared. But in some other cases its action was less satisfactory. Falkenheim tried convallaria in eight cases of heart disease, and found it to exert a decided control over the heart's action and diuresis, but it seemed less certain than digitalis. He gave a tablespoonful of an infusion of the strength of one part of the flowers in twenty parts of water every two hours. Roberts used a liquid extract in doses of ten minims every four hours.

Apocynum cannabinum.—It has long been known that this medicine produces infrequency of the pulse and, in some forms of dropsy, copious diuresis. From its botanical relations Husemann supposed that it contains an active principle affecting the heart in the same manner as digitalin. Schmiedeberg has since isolated two active principles, apocynin and apocynein, which resemble digitalin in properties.

It seems very probable, therefore, that apocynum increases diuresis by acting upon the heart, and that it is specially adapted to dropsy resulting from inefficient cardiac action.

Usually it is administered in the form of an infusion made with a drachm of the bark of the root in eight ounces of water, of which the dose is a tablespoonful at intervals of four to six hours. Excessive doses cause nausea, vomiting, and purging.

Calomel.—The diuretic power of calomel was discovered by Jendrassik and announced by him in 1886. It had, however, been observed long before that calomel, in cases of dropsy, sometimes caused very profuse diuresis; but this was forgotten, and the writers on therapeutics in the two previous decades either entirely ignored the use of calomel as a diuretic, or recommended it only as an adjuvant to squill and digitalis.

The polyuria does not begin on the first day of administration, but usually on the second, the third, the fourth, or the fifth day. The quantity of urine then augments very rapidly, is most profuse on the second day, and subsequently slowly diminishes. As a rule, the polyuria continues until the symptoms of dropsy have completely disappeared. In cases of extensive dropsy the maximum quantity of urine voided in one day was twenty pints.

As the quantity of calomel necessary to produce such profuse diuresis is quite large, the ordinary effects of large doses supervene, unless prevented by prophylactic measures. Diarrhœa nearly always results. If not more than two or three stools occur daily, diuresis may still take place; but if the stools are very numerous no increase of the quantity of urine will result, doubtless because the calomel is expelled from the intestines before absorption can take place. To prevent such rapid discharge of the medicine, opium in small doses should be combined with it.

To prevent the effects upon the mouth, prophylactics should be used from the beginning of the treatment.

Generally chlorate of potassium is preferred, the mouth being rinsed every two or three hours with a three or four per cent. solution of the salt. Jendrassik supposes that an acid reaction in the mouth, especially in the vicinity of decaying teeth, greatly favors stomatitis, and he has used with success a three or four per cent. solution of carbonate of sodium. Tincture of myrrh, tincture of krameria, and permanganate of potassium have also been used as preventives. If, notwithstanding the employment of these means, stomatitis should take place, the use of calomel must be discontinued. But it is not likely to occur, or only very mildly, if the calomel be given in the cautious manner lately recommended by Jendrassik.

Calomel as a diuretic is indicated in cardiac dropsy when other appropriate means, such as digitalis, strophanthus, caffeine, diuretin, etc., fail to give relief. The presence of albumin in the urine does not interfere with the action of calomel, and generally the urine, if it contain albumin, will become normal after the subsidence of the dropsy. It should be recollected that the mere removal of the dropsy does not restore compensation in cases of cardiac insufficiency, and that, after the diuretic has proved successful, it will be necessary to administer remedies to improve the heart's action. Should these not succeed and the dropsy return, calomel should again be used, and, if necessary, it may be employed as often as the dropsy becomes extensive. Its employment at intervals of some weeks becomes necessary in some cases of heart disease in which the rupture of compensation cannot be rectified. If the calomel be carefully used no harm will result, and the patient may be made comfortable and life be prolonged for some years.

The dose of calomel in most of the reported clinical experiments was gr. iij., given from three to five times daily for several days, usually together with gr. $\frac{1}{6}$ of opium to prevent catharsis. Lately Jendrassik has stated, after further experience, that gr. iss. is the best single dose, and that this should be given eight or ten times within a day. After the administration for one day the polyuria, he says, is just as profuse on the third or fourth day as if the medicine had been given on the intermediate days, and that it is certainly erroneous to persist in the administration of calomel after the urine has begun to increase in quantity.

Diuretin.—The term diuretin is applied to a preparation of theobromine, as a convenient substitute for the unwieldy chemical name sodio-theobromine salicylate. As this chemical name indicates, diuretin is a double compound of sodium theobromine, $C_7H_7NaN_4O_2$, and sodium salicylate, $C_6H_4(OH)COONa$. (For further details regarding the characteristics and physiological action of the drug, see the special article on *Diuretin.*)

Christian Gram, of Copenhagen, administered diuretin in cases of dropsy in which other diuretics, digitalis and strophanthus, had failed. He states that he purposely selected cases in which, as a rule, we are utterly helpless. Diuretin always increased the quantity of urine, except in those cases in which the renal epithelium was so degenerated that no action could be expected. In some cases a relative cure resulted, or at least decided improvement, a result that may be called a good one when it is considered that in severe organic heart disease and in chronic nephritis only a relative cure can be attained. The usual dose of diuretin was 1.0 (gr. xv.), which was given five or six times daily. No changes in the circulation took place, and hence the increase in diuresis resulted from a direct action upon the kidneys. The remedy never produced disagreeable incidental effects, and only once, in a very cachectic patient, did it cause slight giddiness.

A. Hoffman tried diuretin in numerous cases. In four cases of cardiac dropsy he employed it on fourteen different occasions, and always obtained good results. Usually diuretin was not given until digitalis had failed to act. The polyuria began on the first day of administration, augmented gradually, and reached the maximum in from two to six days. It rapidly diminished when the diuretin was withdrawn, or when the dropsy had subsided. Sometimes the diuretic action was delayed for several days, perhaps on account of slow absorption. The quantity of urine voided depended upon the extent of the dropsy; when this was very decided the quantity at the maximum amounted to five or six litres a day.

Dr. Koritschoner employed diuretin in thirty-eight cases of severe dropsy of cardiac, renal, and hepatic origin. In twenty-three cases the effect was better than from other diuretics, and in eight of them very remarkable, the quantity of urine having increased to ten or twelve litres. In ten cases the effect was moderate, but was not excelled or equalled by any other diuretic. Only in one case was complete failure observed. On the average the action of diuretin was best in cardiac dropsy, next in portal obstruction, and least in nephritis. But this pertains only to the absolute action; relatively to other diuretics the action in chronic Bright's disease was very satisfactory. Koritschoner supposes that diuretin acts directly upon the kidneys, as he observed no influence on the heart. He knows of no contraindications to its use. Even when employed for a long time it proved innocuous. He began with 4.0 (ʒ i.) daily, and increased by 1 gm. daily until the quantity of urine, compared with the ingested fluid and the subsidence of the dropsy, gave a satisfactory result. In sixty per cent. of the cases 5.0 daily sufficed; in thirty per cent., 6.0 daily; and in ten per cent., larger doses up to 10.0. The medicine was given in solution, made with hot water, in tablespoonful doses, at intervals of one or two hours, beginning three hours after the principal meal.

R. Demme tried diuretin with good results in dropsy occurring in children. The dropsy of scarlatinous nephritis seemed, after the first stage of the nephritis had passed, to be removed more rapidly by diuretin than by all other diuretics. Anasarca and effusions in the serous cavities resulting from mitral insufficiency subsided, after the valvular disease had been compensated by digitalis, very speedily when diuretin was given. The dose for children from two to five years old was 0.5 to 1.5, and for those from six to ten years old, 1.5 to 3.0 daily. Diuretin should not be given to infants under one year, as in them it easily causes irritation of the stomach and intestines.

Von Schroeder states that some preparations of diuretin found in commerce contain only from thirty to thirty-eight per cent. of theobromine, as found in the analyses made by Vulpius. Knoll's preparation was found to contain forty-eight per cent., and hence should be preferred by the practitioner. Von Schroeder recommends the following formula:

℞. Diuretini (Knoll)	5.0–7.0
Aq. destill.	90.0
Aq. menth. pip.	100.0
Syr. simpl.	10.0

M. S.: One tablespoonful every two or three hours.

STIMULANT OR IRRITANT DIURETICS.—This group includes all direct diuretics that increase the urinary secretion when used in moderate doses, but diminish it and produce various symptoms of severe irritation or inflammation of the kidneys when given in excessive quantities. They differ greatly from one another in the degree in which they manifest these properties, in some the diuretic, in others the irritant property, preponderating. Only the former are useful in cases requiring an increase of diuresis. Those most frequently employed are juniper, scoparius, and resin of copaiba.

Juniperus.—Besides a volatile oil, juniper berries contain a notable quantity of alkaline salts. Their diuretic action is usually attributed solely to the volatile oil, but the fact long observed that the infusion is more efficient than a corresponding quantity of the oil, shows that the salts exert a decided effect.

Juniper is frequently used as a diuretic in the forms of dropsy due to heart disease, affections of the lungs interfering with the circulation, and contracted kidneys. Without other remedies acting directly on the heart, so as to increase the arterial blood pressure, it is not very effective. Hence it is generally combined with digitalis, squill, and sweet spirit of nitre, as in the following well-known formula: ℞ Ol. juniperi, ʒ ss.; spiritus ætheris nitrosi, tincturæ digitalis, āā ʒ iij. M. Sig.: From twenty to thirty drops every three hours.

In very large quantities juniper, especially its volatile oil, may excite much irritation of the kidneys, and cause the urine to become bloody, albuminous, and very scanty. Hence it is contraindicated in all cases of dropsy in which the kidneys are inflamed. It is, however, sometimes employed in the dropsy following scarlatina, but only in the form of infusion, with saline diuretics. It should never be employed until other methods of treatment have relieved the kidneys.

The following formula has been much used to hasten the absorption of inflammatory effusions: ℞ Infusi juniperi (extr. ℥ ss.), ℥ vi.; potassii acetatis, ʒ iij.; syrupi scillæ, ℥ ss. M. Sig.: One tablespoonful every two hours.

Scoparius.—This medicine is highly esteemed as an active diuretic by English physicians. Stillé holds that no diuretic is entitled to more credit than broom for removing dropsical effusions. Administered in ordinary doses, it decidedly increases the urinary secretion, and sometimes also the action of the bowels. Excessive doses may cause vomiting, purging, and irritation of the urinary organs.

Scoparius contains two proximate principles, scoparin, a neutral substance, and sparteine, a volatile liquid alkaloid, besides a notable quantity of potassium salts. Its diuretic power is partly attributable to the salts, but chiefly to scoparin, which was found by Stenhouse to produce very great increase of the urinary secretion in doses of gr. iij. to vii. According to Fronmüller it acts when applied hypodermatically in doses of half a grain, and in normal as well as abnormal states of the organism.

Scoparius is usually employed in the form of a decoction containing one part in twenty. Of this the dose for an adult is about two ounces, at intervals of from three to six hours. It may be employed in any form of dropsy, if the kidneys are healthy. Pulmonary congestion and inflammation are said to contraindicate its use. Frequently the decoction of scoparius is combined with other diuretics, as in the following formula: ℞ Potassii acetatis, ʒ ij.; syrupi scillæ, ℥ ss.; decocti scoparii (B. Ph.) ad ℥ vi. M. Sig.: One tablespoonful every two hours.

Resina Copaibæ.—In some forms of dropsy, especially in ascites, the resin of copaiba has been found to be a very active diuretic. In 1872 Wilks called attention to this property of the resin. He had succeeded with it in numerous cases of dropsy, but particularly in ascites, after other remedies had failed. It acted less certainly in cardiac dropsy, but sometimes produced decided diuresis when other remedies had been powerless. Brudi and others have also reported decided success in ascites, and in a few cases of cardiac dropsy. Frederick Taylor, who used the resin in more than sixty cases of different forms of dropsy, fully confirms these observations.

The dose of the resin varies from gr. v. to xx., which may be given three or four times daily. In excessive doses it may produce great irritation of the stomach, intestines, and kidneys. The urine of patients taking the resin may throw down a precipitate, on the addition of nitric acid, which may be mistaken for albumin. It may be readily distinguished from the latter by its disappearance on the addition of alcohol.

Wilks gave gr. xv. or xx. of the resin in mucilage and flavored water three or four times a day.

Oleum Terebinthinæ.—In small doses, ♏x. to xx., at intervals of three or four hours, oil of turpentine slightly increases the urinary secretion and imparts to it an odor of violets. Large doses, from ʒ ss. to ij., repeated several times, soon cause marked irritation of the kidneys, manifested by diminished secretion of urine, which may be bloody and albuminous, and by frequent micturition.

Since oil of turpentine is incapable of causing decided diuresis, it is never employed in dropsy. But in catarrhal affections of the genito-urinary tract it is frequently employed, as it usually soon diminishes the amount of mucus and pus in the urine. Thus, in cystitis, Edlefsen found that it ameliorated the dysuria, restored the acid reaction of the urine, and arrested the purulent discharge in doses of ♏ x. given five times daily.

Rossbach investigated the action of oil of turpentine on the mucous membrane of the trachea. Air, passed through the oil so as to become saturated with it, forcibly projected against the mucous membrane, arrested the secretion of mucus. A watery solution containing one or two per cent., dropped upon the tracheal mucous membrane, caused an increase of secretion, but greatly diminished the supply of blood. It is held that a similar action on the blood-vessels takes place in catarrhal affections of the urinary passages, in consequence of which the morbid action ceases.

Oil of turpentine acts destructively on low organisms. This property is still further increased by the free oxygen which the oil usually contains (Binz). Hence it is very probable that the beneficial effects of the oil in putrid processes of the respiratory and urinary mucous membranes are chiefly due to its destructive action on the low organisms always present under such circumstances.

Oil of turpentine is administered in gelatin capsules, or in emulsion with gum arabic, oil of almond, or yolk of egg. ℞ Olei terebinthinæ, olei amygd. expres., āā ʒ i.–ij.; mucil. acaciæ, syrupi, āā ℥ ss.; aq. destill., ℥ iij. M. Sig.: One tablespoonful three times a day.

Copaiba.—In small doses, ♏ x. to xx., this oleoresin usually somewhat increases the quantity of urine, and imparts to it a darker color and a peculiar odor. It also renders the urine aseptic, so that it resists putrefaction for a long time.

Large doses, ʒ i. to ij., are apt to cause irritation of the kidneys, marked by diminished secretion, frequent micturition, and even hæmaturia. Often, however, such doses are well borne.

Copaiba is doubtless able to produce very decided diuresis, and it was quite frequently employed in dropsies before it was known that the diuretic power is chiefly attributable to its resinous constituent.

The oleoresin is often decidedly useful in catarrhal affections of the genito-urinary mucous membrane, especially in those of specific origin. In cases of cystitis with alkaline urine, copaiba often rapidly restores the normal acid reaction. Edlefsen, and numerous other observers, have reported speedy amelioration of all the symptoms of cystitis. Binz holds that the constituents of copaiba, or the products resulting from their oxidation in the organism, passing into the urine, paralyze the cells about to escape from the vessels, prevent alkaline fermentation, and weaken the energy of infectious bodies. The utility of copaiba in gonorrhœa is doubtless chiefly due to its antiseptic action.

Copaiba is given in doses of ♏x to ʒ i. Rarely are doses exceeding half a drachm required. It is administered in gelatin capsules, or in emulsion with gum arabic and sugar.

Cubeba.—In moderate doses cubeb increases somewhat the urinary secretion. In excessive doses it may diminish the urine and render it bloody. Some individuals are very sensitive to its action and may suffer from irritation of the kidney after several drachms of the powdered drugs have been administered.

Cubeb is frequently employed in gonorrhœa and other catarrhal diseases of the mucous membrane of the urinary passages. Binz maintains that the resinous acid existing in the cubeb, or formed in the organism by oxidation of the oil, in flowing for several days over the affected mucous membrane, lowers the vitality of the gonococci in the same manner as do injections of bichloride of mercury and other substances.

The dose of cubeb varies from gr. x. to ʒ i. The oleoresin is administered in doses of ♏x. to xxx., usually in gelatin capsules, or in emulsion.

Oleum Santali.—According to numerous observers the oil of yellow sandal-wood possesses properties analogous to those of copaiba. In doses of ♏x. to xxx. it imparts a peculiar odor to the urine and rapidly modifies the symptoms of catarrhal inflammation of the genito-urinary mucous membrane. According to Keyes, it is less effective in true gonorrhœa than in ordinary urethritis, though sometimes it rapidly diminishes the discharge and scalding. In excessive doses it is productive of severe irritation of the kidneys, marked by intense pain over the regions in which these organs are located.

The dose of sandalwood oil is from ♏x. to xx. It is usually administered in gelatin capsules, each containing ten drops, or in emulsion.

The following medicines stimulate the kidneys, but their diuretic action is not very decided, and hence they are not often employed in cases requiring an increase of the urinary secretion. They also exert a decided influence on the mucous membrane of the urinary passages, especially noticeable when a catarrhal state is present, as in pyelitis, cystitis, and urethritis. They are: chimaphila, buchu, uva ursi, pareira, petroselinum, taraxacum, erigeron canadense, carota, armoracia, and cantharis.

INDIRECT DIURETICS.—To this group of diuretics belong all medicines which modify the heart's action so as to increase the general arterial blood pressure. As the urine secreted during their action is copious and watery, they are often called hydragogue diuretics.

Digitalis.—In healthy persons digitalis exerts no obvious effect on the quantity of urine secreted, unless it be taken in excessive doses, or be too long continued, when the quantity becomes lessened. In cardiac dropsy it usually produces its action upon the kidneys as soon as the heart's action becomes slower and stronger, and the general blood pressure is increased. When the cardiac failure is so profound that digitalis cannot invigorate the ventricular contractions, it completely fails as a diuretic.

Digitalis is indicated as a diuretic in cardiac dropsy; that is, whenever an abnormal accumulation of serum in the areolar tissue, or in a serous cavity, is the result of inefficient heart action, and hence of general venous congestion. Digitalis is therefore applicable in the forms of dropsy due to valvular disease, degeneration of the hypertrophied heart, fatty heart, and dilatation of the right ventricle in consequence of chronic bronchitis and emphysema, or other pulmonary diseases.

Digitalis is always contraindicated when the pulse is strong and hard. In all cases it must be very cautiously given, as after some days, without having produced any obvious effects, it may suddenly act with unexpected severity. The cause of this cumulative action is not known. Schmiedeberg supposed it to be due to slow absorption and apparently slow elimination of its active principles. As a rule, its use should be interrupted as soon as the pulse has become slower and diuresis has increased. The following symptoms are regarded as cumulative effects, and their occurrence requires immediate discontinuance of the medicine: Decided slowness and irregularity of the pulse, nausea and vomiting, severe headache, dimness of sight, giddiness, sleeplessness, and delirium.

The initial dose of digitalis is gr. i. or gr. ij. three times daily. If it be necessary to repeat the dose every two or three hours, the patient should be visited twice daily.

Scilla.—Squill is a diuretic of very decided power, often in a few days greatly increasing the quantity of urine, when before it was very scanty. It is not, however, equally active in all forms of dropsy, manifesting little influence when the effusions are due to organic alterations of the kidneys or liver, or to inflammations of serous membranes.

Formerly it was held that squill acts directly on the secreting structures of the kidneys, since excessive doses were sometimes followed by strangury and bloody urine. But the experiments of Husemann on animals, in which toxic doses produced no marked changes of the kidneys, show that squill exerts a very slight, if any, direct influence. On the contrary, the recent investigations of Drouot, Jarmersted, and Husemann and König render it certain that its diuretic action takes place in consequence of a modification of the heart's action. In its action upon the heart it closely resembles digitalis, influencing it, however, more rapidly and less durably. The slowing and strengthening of the pulse, which in man indicate an increase of the blood pressure, usually continue for only a few hours after ordinary doses.

The indications for the use of squill as a diuretic are the same as for digitalis. It is, perhaps, less efficient in cardiac dropsy than the latter remedy, but is often combined with it, as the combination acts more rapidly and effectually than either medicine alone.

Squill is often administered in the dropsy occurring in anæmic and cachectic patients, generally together with iron and quinine.

The dose of squill is from gr. i. to iij., administered from three to six times a day. In excessive doses it rapidly disorders the stomach, but never produces cumulative effects; hence it may be continued for a long time in moderate doses without risk.

Squill is generally supposed to be contraindicated in acute nephritis and in all forms of Bright's disease. There is, however, no evidence that it causes decided irritation of the kidneys. *Samuel Nickles.*

DIURETIN.—This name was given by Dr. Christian Gram, of Copenhagen, to the salicylate of theobromine and sodium which he introduced as a substitute for caffeine. Professor Schroeder, of Strasbourg, had experimented with the alkaloid theobromine, and had reported upon its important diuretic properties at the meeting of the German Medical Congress in 1889. He had found that caffeine in small doses often failed to produce diuresis, and when the vascular tension of the kidneys was increased, the flow of urine sometimes diminished on account of the increased blood pressure produced by the caffeine. Large doses overcame this effect, but they were liable to cause nervousness and insomnia, and other distressing symptoms. Theobromine he found to be an equally efficient diuretic without producing any nervous symptoms or affecting the blood pressure; chemically, it differed from caffeine by containing one equivalent less of methyl, it being the dimethyl-xanthin and caffeine the trimethyl-xanthin. The difficulty in using the alkaloid was its insolubility, it requiring 1,600 parts of water for its solution. At his suggestion Dr. Gram instituted a series of experiments, and succeeded in producing a soluble salt by combining it with salicylate of sodium. It is said to be prepared by dissolving one molecule (180) of theobromine in one molecule (40) of soda hydrate, and adding to the solution one molecule (160) of salicylate of sodium; when evaporated to dryness it should yield 362 parts of the double salt, which theoretically contains 49.7 per cent. of theobromine and 38.1 per cent. of salicylic acid. It is a white powder with a slightly bitter and disagreeable taste, very soluble; by the aid of heat it dissolves in less than half its weight of water, and no precipitation occurs upon cooling. Its solution is very unstable and rapidly decomposes. It burns without leaving any residue.

To estimate the amount of the alkaloid an aqueous solution is acidified, then made alkaline with ammonia, and the precipitated theobromine collected on a filter, washed, and dried. The amount of salicylic acid may be determined by treating the filtrate and washings with ether, separating the ethereal solution, and evaporating.

Theobromine exerts its diuretic properties by its direct action on the secreting tissue of the kidneys. It acts promptly and energetically, and its effect is maintained for a day or two after the withdrawal of the drug. Its action is not cumulative. The solids as well as the fluid are increased. It has a mild action on the circulation, very similar to that produced by caffeine; there is no marked change in the blood pressure, but the heart becomes slower, stronger, and less irregular. An improvement in the general condition of the patient is also experienced. Reports of its prolonged use show that it may be accompanied by heat and burning at the epigastrium, anorexia, diarrhœa and other signs of gastric and intestinal irritation. In all forms of dropsy due to renal disease its action is most efficient; there is no irritant effect on the secreting cells, and no unfavorable results follow its use. It is of service in all dropsies accompanying heart disease. When digitalis and other cardiac tonics have been used without success, diuretin will often be found to succeed, by its action on the kidneys following that of the other forms of diuretics. A combination of digitalis and diuretin will form a very active diuretic mixture in dropsies in which the blood pressure requires to be raised. It has not been found to be of so much value when the dropsy arises from inflamed serous membranes, or from hepatic disease. The following are the conclusions of Dr. Dujardin-Beaumetz:

(1) When given in doses of gr. xv. it is a much stronger diuretic than caffeine; (2) when there is considerable cardiac degeneration it should be used with some caution, especially when albuminuria is also present; (3) under its influence the cardiac contractions are scarcely affected; (4) diuretin rapidly increases the quantity of urine passed, and the diuretic effect lasts twice or three times as long as that produced by caffeine; (5) the activity does not wear off as the patient becomes accustomed to the drug; (6) micturition is not rendered difficult or painful; (7) diuretin has no action on the central nervous system.

The dose is from gr. lx. to xc. daily. It has been found most active in gr. xv. doses every two or three hours, in water with some aromatic essence to disguise its bitter taste. Care should be observed in selecting the remedy, on account of its instability. When exposed to the atmosphere it absorbs carbonic acid and separates the alkaloid, which is insoluble. The addition of acids or acid vegetable juice also decomposes the solution by throwing down the alkaloid. It has been found a safe remedy for children above one year of age, and has proved of marked benefit in scarlatinal nephritis. At the age of from two to five years the dose may be from gr. viij. to xxv. in the day, and at the age of from six to twelve, from gr. xxv. to xlv. The total amount for the day may be dissolved in four ounces of water with ten or twelve drops of brandy and a little sugar. It has been given for weeks without producing any ill effects and without any diminution of its therapeutic action.

Beaumont Small.

DIXIE SPRINGS.—Knox County, Tennessee.

Post-Office.—Knoxville. Hotels in Knoxville.

The Dixie Mineral Spring is an artesian well, 185 feet deep, located just across the Tennessee River, now within the city limits of Knoxville. The location is on the northern slope of the foothills and about 1,000 feet above the sea level. The situation of the spring is a charming one and commands a magnificent view for miles up and down the beautiful Tennessee valley. The water was struck after boring 185 feet through solid rock. It has a temperature of about 58° F. the year round. The following analysis was made by J. W. Slocum, analytical chemist:

One United States Gallon Contains:

Solids.	Grains.
Calcium carbonate	14.90
Sodium chloride	110.35
Sodium sulphate	9.70
Sodium bicarbonate	146.91
Potassium nitrate	.60
Lithium chloride	Trace.
Magnesium carbonate	23.30
Magnesium chloride	.54
Magnesium sulphate	6.18
Iron carbonate	.60
Alumina	.30
Silica	.36
Total	313.74

This analysis shows a very valuable water of the alkaline-saline-muriated variety. It resembles the Vichy and Seltzer Springs of Saratoga, but contains less lime than those celebrated waters. This water has been found very useful in dyspepsia, biliousness, and constipation. The water has diuretic, laxative, antacid, and also mild tonic effects. It has an extensive sale in Tennessee and the adjoining States.

James K. Crook.

DOCK.—Rumex. "The root of *Rumex crispus* L. and of some other species of *Rumex* (fam. *Polygonaceæ*)" (U. S. P., but likely to be dropped from the forthcoming edition.) *R. crispus* is known as "Curly," *R. obtusifolius* as "Yellow" Dock. Both are pernicious perennial weeds from Europe, with long stout roots and tall wand-like stems, the greenish flowers and three-cornered, winged, reddish-brown fruits growing in dense, narrow, pyramidal panicles. Both have leaves a foot or two in length. Those of the yellow dock are broad, nearly plane and blunt. Those of curly dock are only two or three inches broad, tapering and acute, of a darker green and with the margin much crisped. The leaves, especially of the latter, are used as a well-known pot-herb, having laxative properties. Its root is also preferred to the other in domestic medicine and is narrowly fusiform, from six inches to nearly two feet in length and reaching something more than half an inch in thickness. It is little if at all branched, somewhat annulate above, deeply wrinkled below, deep reddish-brown without, whitish (if fresh) within, and with reddish medullary rays, becoming brown throughout by long keeping. The fracture is short. It has a slight characteristic odor and a bitter, astringent, slightly mucilaginous taste. The root of the other is similar, but is not so long, and usually divides just below the surface of the ground into a number of more slender, parallel branches.

The important constituents are chrysophanic acid, tannin, and an amaroid, with starch and gum. The herbage especially contains much oxalic acid. The immediate effect of rumex may be either astringent or laxative, according to the conditions, usually the former. The fresher the root and the larger the dose, the more likely, usually, is the irritant chrysophanic acid to overcome the tannic acid and act as a laxative. It unquestionably exerts a beneficial tonic or alterative action, favoring the elimination of waste matter and stimulating both appetite and digestion. It produces, however, no striking effects and has fallen into contempt. The dose of the fluid extract is 2 to 8 c.c. (fl. ʒ ss.–ij.).

Henry H. Rusby.

DOGWOOD, FLOWERING.—Cornus. The inner bark, preferably of the root, of *Cornus florida* L. (fam. *Cornaceæ*). The genus contains some thirty species distributed through the north temperate zone, a few getting into the tropics, in the mountains. They abound in bitter substances and tannin and act generally like the one here discussed. Several have been official, this being the last discarded. *C. florida* is a small tree, from twelve to thirty feet high, with slender, spreading branches, hard wood, ovate, pointed leaves, and very showy flower clusters. These are each supported by four large, broadly obovate and notched, white or purplish, petaloid bracts, which make the whole look like a large whitish flower; the real flowers, however, are minute, greenish-yellow, and closely aggregated in the midst of these bracts. Fruit clustered, small, scarlet, two-seeded drupes. It is common in the middle and southern portion of the United States, rarer and smaller in northern New England. When thrifty, it is very showy in blossom, and pretty also when the fruit is ripe.

Dogwood bark is in irregular flattish pieces, or in quills from 2 to 4 mm. thick ($\frac{1}{8}$ in.), and of varying length. Both surfaces and the texture are reddish, in the stem bark rather dull, in the root bark a deep crimson purple. The outer surface is smoothish; the inner finely but prominently reticulate striate, and hard to the touch, almost like fine sand paper; the fracture is short and brittle; the texture hard. Taste, bitter and astringent; odor, none. Dogwood is exclusively an American remedy.

It contains the amaroid *cornin*, in white, silky, very bitter crystals, soluble in alcohol and water. *Tannic acid*, *sugar, fatty oil*, and *resin* are among the other constituents. The cornin and the tannin are its active principles. Cornin has been used as a substitute for and an adulterant of quinine.

Action and Use.—There is no reason to suppose that this medicine is anything more than a slightly astringent, bitter tonic; as such, however, it is good and useful. It was one of the drugs proposed as a substitute for cinchona in the treatment of intermittents, and, like them all, has been completely set aside by the general use of quinine. The fluid extract is given in doses of 1 to 4 c.c. (♏xv. to lx.), but the use of the tincture is preferable.

Henry H. Rusby.

DOGWOOD, JAMAICA.—Piscidia. The bark, preferably of the root, of *Ichthyomethia Piscipula* (L.) Kuntze (*Erythrina Piscipula* L.; *Piscidia Erythrina* Jacq.) (fam. *Leguminosæ*), a large West Indian tree yielding a valuable wood. Its use as a fish poison is ancient. It is crushed and prepared, then dragged through the water in baskets, the fish being quickly narcotized and then easily caught. It has also had for a long time a local reputation for relieving pain, especially toothache, which was treated by applying it, or some preparation of it, locally, in the carious cavity. In this country it has been used for various conditions, generally including pain of so-called nervous character, with uncertain, but on the whole favorable, results. Judging from the published reports, it has been more used in the Western and Southern States than in the East.

The drug occurs for the most part in strips, from six inches to two feet long and up to six inches in breadth. These strips are usually more or less curved, the smaller ones sometimes quilled, the larger sometimes flat, but warped. The thickness of the bark varies from one-twelfth to one-fourth inch. The bark of the root is in shorter and smaller pieces, more irregularly curved, and less fibrous and tough. It is grayish or yellowish-brown and often mottled externally, dark brown and fibrous next the wood, frequently with large patches looking as though stained of a bluish-green. Upon fracture, the central tissue is seen to be dark green. Odor narcotic; taste disagreeable, acrid.

It contains resin, the crystalline amaroid *piscidin* ($C_{29}H_{24}O_8$), soluble in hot alcohol, and a water-soluble glucoside which is apparently the fish-stupefying agent. The "piscidin" of the market is not a chemical body but merely a resinous extract.

Jamaica dogwood appears to have decided narcotic powers over most animals, it certainly does in a marked degree upon fish, as its original use shows, and in case of frogs and several kinds of higher animals it exhibits the same qualities. The following summary is from experiments by A. C. Nagle: "It is a narcotic to higher as well as lower animals. It dilates the pupil, it causes an increase in the respiration, followed by a sudden decrease; produces salivation and profound diaphoresis; reduces the action of the heart, producing general paralysis and death by asphyxia. It has little effect upon the temperature." In therapeutics it has been tried with good results in neuralgia, headache, hysteria, "phantom tumor," "nervousness," melancholia, prodromic labor pains, neurasthenic pains of various places, etc., as well as for some inflammatory pains, such as those of iritis. It also serves a good purpose as a hypnotic in restlessness, alcoholic wakefulness, etc. For certainty and uniformity of action it is not to be compared with opium or chloral, and disagreeable feelings sometimes follow its administration, as well as that of these more powerful drugs. The fluid extract is usually given in doses of 2–4 c.c. (fl. ʒ ss.–i.).

Henry H. Rusby.

DOGWOOD, POISON. See Rhus, under *Poisonous Plants.*

DOLOMOL is a mixture of the stearates and palmitates of calcium and magnesium. On account of its smooth texture and neutral character, it is recommended as a dusting powder for the skin. It may be used alone or mixed with boric acid, calomel, resorcin, sulphur, etc. With sodium bicarbonate it forms a soothing application to superficial burns.

W. A. Bastedo.

DOLORES.—Nuevo Leon, Mexico.

About 40 km. to the south of Linares, on the Fresno estate, is found a sulphur spring called Dolores. This spring has been classified as a sulphureted lime spring, the water is quite cold, and sometimes during very dry seasons the spring runs dry. In spite of this drawback the curative properties of the water are so well known that large numbers of people are attracted to the place in the hope of relieving rheumatic ailments and diseases of the skin.

No quantitative analysis has as yet been made of this water; we only know that it contains a large quantity of sulphurous acid.

N. J. Ponce de Léon.

DOSAGE.—Under this title will be discussed the principles that determine standard dosage, and the circumstances that necessitate modification of such dosage.

1. Standard Dosage.—The word *dose*, in connection with the matter of the administration of medicines, is used in two distinct senses, which must carefully be discriminated, as follows: In one sense the dose of a medicine may be taken to mean the quantity necessary to produce a certain therapeutic effect for the time being, and in another acceptation the same word signifies the quantity to be administered in a single portion. Very frequently the two doses, in these two senses, are identical —the quantity necessary for an effect being given all at once—but very often again they are not. Thus gr. xx. of quinine—a *dose* of that medicine for an antipyretic effect—may be *administered* in four individual *doses* of gr. v. each, taken at short intervals.

Dose, in the sense of quantity necessary for a given effect, is, of course, determined by trial. In stating doses in this sense, the point must be regarded whether the effect sought is to be a passing one only or a continuous one. In the former case the dose can categorically be stated, as, for instance, that the purgative dose of castor oil is a tablespoonful; but in the instance of a continuous effect such categorical statement is impossible, since dose now refers to the quantity necessary to be present in the blood at any single moment. Dose, in such case, must be stated in terms of the amount required to be given within a certain period for the maintenance of the necessary impregnation of the system. In such statement the period most convenient, and therefore most commonly used, is the term of twenty-four hours. So, for instance, we say that the dose of a bromide as a single sleeping draught is simply so much; but we state the dose of the same medicine for the controlling of epilepsy at *so much a day*, since now a certain grade of bromism must be maintained unremittingly for months or even years.

Standard dosage never can be set at a precise figure; in the first place, because therapeutic achievements do not permit of precise mensuration, and, secondly, because the factors that determine degree of medicinal effect are many and impossible of exact estimate. All posological tables, therefore, must be taken to exhibit only averages. Individual medicines may have more than one standard dosage if they subserve different purposes attained by different dosage. Thus quinine has one dose as a simple bitter stomachic, but another and quite different one as an antipyretic.

Dose, in the sense of *amount to be administered in one portion*, is, of course, based primarily on dose in the foregoing sense, but is also affected by other considerations. In cases in which a transient effect only is wanted, the rule is to give the whole dose at once, unless there be positive disadvantage in so doing; and that practically means unless the whole dose, swallowed in single portion, would be likely to disorder the stomach. In such case the charge is given, as the phrase is, in *divided doses;* that is, in moieties administered in even succession at intervals long enough to save the stomach, but short enough to secure the practical presence of the whole charge in the blood at once.

In cases in which the medicinal impression is to be continuous, the daily allowance is to be given in such division of dosage as will best harmonize the conflicting considerations of maintaining an equable impression on the one hand, and avoiding an undue disturbance of the patient on the other. For the one consideration calls for administration by frequent small moieties, and the other, on the contrary, for the minimum of frequency. Practically, the rule is to dose no oftener than necessary for the maintaining of a fairly equable impression, and to reduce this frequency still further if it disturbs the patient, or his stomach, unduly. The amount of each dose will be determined by the frequency. In following out this rule, the first thing to find with a given medicine is that minimum of frequency of giving which will attain a practical equability of effect. This minimum will differ enormously with different drugs—a fact often not properly recognized,—being determined by the relation between rate of absorption and elimination, a rate which varies greatly among medicines. In a general way, compounds of the heavy metals are slow of elimination, whence follows the fact that a mercurial impression is practically equable with a renewal of doses, by the mouth, of no greater frequency than thrice daily, or, by inunction or fumigation, once daily; and, similarly, that tonic doses of iron hardly require more frequent giving than three times a day. Salts of the alkalies of high diffusion power, however, are much more rapidly eliminated; so that to maintain an equable effect with them the daily allowance, in continuous medication, should be broken up into four charges at least, and a distribution into six may in many cases be distinctly advantageous. The alkaline iodides and bromides are prominent examples of this class of medicines, and the best therapeutic effects of these salts are often missed through the error of giving at too long intervals. Diffusible alcohols and ethers must be given more frequently still, if the effect is to be maintained with any approach to equability, and the same is true also of many neurotic alkaloids. A prominent example in point among alkaloids is aconite, which, given for the purpose of reducing heart action, should be administered at least hourly, the amount given on each occasion, of course, bearing proper relation to the frequency.

The second consideration is so to grade the frequency that the individual doses will be small enough not to derange the stomach, nor, constitutionally, to produce an initial over-great effect. Here again the importance of the consideration is often overlooked by prescribers, and a patient is unnecessarily sickened, or his functions are unduly perturbed, by large infrequent dosage, when precisely the same therapeutic effect from the medicine could have been gotten without distress or without derangement by the same dosage broken up into more frequent, and hence smaller, individual charges.

But while there is, thus, an advantage in dosing, for continuous impression, by the method of "little and often," yet the consideration of the disturbing of the patient forbids the carrying of the method to extremes. This consideration is serious in cases of slight indisposition on the one hand, and of desperate illness on the other. In the one case the patient, not too sick to attend to his ordinary avocations, is intolerably annoyed by an over-frequent dosing, and in the other the subject, ill nearly unto death, and needing the most careful nursing of his fast-ebbing vitality, is likely to have his life literally worried out of him by incessant wakings and liftings to swallow medicine.

An important factor affecting standard dosage—whether dose for a transient or a continuous effect—is the *bulk* of the subject, since obviously, for constitutional effect of constant degree, the amount of drug must be proportioned to the amount of blood in which the drug is to be dissolved. This consideration obtains especially in prescribing for children. To meet the case of the necessary scaling of doses to fit the varying bulks of this class of patients, several formulæ have been devised, of which the two in commonest use—Young's and Cowling's—work by the *age* of the subject, on the presumption—true enough for the purpose in hand—that children of a given age are of a given bulk. Young's rule is that, taking the adult dose at unity, the fraction thereof proper for a child of given age is expressed by the formula $\frac{\text{age}}{\text{age} + 12}$. At age six, for instance, the fraction is $\frac{6}{6+12} = \frac{6}{18} = \frac{1}{3}$, *i.e.*, a child six years old should be given one-third of the dose proper for an adult. Cowling's formula is, under the same premises, $\frac{\text{age at next birthday}}{24}$. At age six, by this formula, the proper fraction of the adult dose is $\frac{7}{24}$ = a little less than $\frac{1}{3}$. In general, with the younger ages, Cowling's formula yields a slightly smaller dosage than Young's. A formula much less used, because of its inconvenience, is Clarke's, wherein actual weight, instead of age, determines the dose. In this formula, standard dose being unity, the dose for a subject of given weight is expressed by a fraction of which the numerator is the number corresponding to the weight in avoirdupois pounds, and the denominator is the arbitrary number 150, corresponding to the weight, in pounds, of the average human adult.

2. CIRCUMSTANCES NECESSITATING MODIFICATION OF STANDARD DOSAGE.—These circumstances, which are many and potent, are as follows: *Age*, apart from the consideration of bulk of subject, calls for special adjustment of dose in the case of many medicines. In general, children are more susceptible to drug influence than adults, and this fact obtains strikingly in the instance of opium. In general, furthermore, both extremes of age bear actively perturbing medication badly. *Sex* is another element to be considered in adjusting dosage—women, bulk for bulk, being generally more susceptible to medicines than men, and particularly so as regards neurotic drugs. *Climate* also must be regarded, with especial reference to the fact that in warm weather the digestive system is unduly sensitive, and the system generally more susceptible to depressing influences. *Custom* may affect dosage powerfully, sometimes by enhancing, but more commonly by lessening, normal effects. This lessening is seen markedly in the case of the strictly neurotic effects of so-called neurotic drugs, such as opium or alcohol, although with this same class of drugs—a fact often overlooked—the effects *other* than neurotic may be wholly uninfluenced, or even enhanced in intensity, by habit. Thus, for instance, appears the curious anomaly in the case of the confirmed toper that with ever-increasing indulgence he gets not any more *drunk* than before, in the commonly understood sense of the word, but yet *does* get progressively more and more catarrhal as to his stomach and bowels, more cirrhotic as to his liver, more apoplectic as to his brain, and more debased as to his memory, manners, and morals, with every drop added to his daily allowance of liquor. *Idiosyncrasy* is another important factor in dosage, working now to increase, and now to lessen, the standard; and, lastly, *physiological status* must be regarded, since, in practice, morbid conditions may modify profoundly normal susceptibility to medicinal influences. A notable instance of this circumstance is, once more, in the case of neurotic drugs, which, in conditions of great devitalization, require very much larger doses than normal to produce normal grades of effect. Thus a subject at death's door from a sudden voluminous loss of blood may swallow doses of opium or of brandy that would actually be fatal in health, but now with no other effect than to sustain the failing heart and nervous system until natural recuperation begins. In actual prescribing, therefore, particularly of neurotic drugs, the wise physician regards posological tables as furnishing points of departure, only, for the increase or diminution of standard dosage according to the condition of the patient.

From all the foregoing two corollaries appear, of obvious practical importance—the one that dosage for a given drug cannot be set at one categorical figure; and the other that, even with given conditions, dosage never can be estimated with any approach to precision.

Edward Curtis.

DOUBLE MONSTERS. See *Teratology.*

DOXTATTER'S MINERAL WELL.—Monroe County, New York.

POST-OFFICE.—Rochester. Hotels.

This well is described in some of the older works as Longmuir's Well. It is located in the city of Rochester. An analysis by L. C. Beck, many years ago (1842), resulted as follows:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium bicarbonate Magnesium carbonate Iron oxide	11.84
Sodium sulphate	55.92
Calcium chloride	52.16
Total ingredients	119.92
Gases.	**Cubic inches**
Sulphureted hydrogen	17.28
Carbonic acid	Trace.

This analysis is evidently incomplete. It shows sufficient sulphate of soda to give it aperient properties. The water is also highly charged with sulphureted hydrogen.

James K. Crook.

DRACONTIUM. See *Skunk Cabbage.*

DRACUNCULUS MEDINENSIS. See *Nematodes.*

DRAGON'S BLOOD.—RESINA DRACONIS (*Sang dragon*, Codex Med.). A deep-red resin which exudes spontaneously from the ripe fruits of *Calamus Draco* Willd. (fam. *Palmaceæ*), one of the rattan palms of Borneo, Java, and other Polynesian islands. It is collected by shaking the ripe fruits in a basket, sifting out the resin and, by means of warmth, moulding it into little balls, or more usually into slender sticks, 20 or 30 cm. long and about as thick as the finger. These are wrapped in pieces of leaves and tied. Inferior qualities are made by boiling out the resin from the fruits, and hardening it in masses. Large, brilliant red cakes should be looked upon with suspicion, as they are apt to be heavily adulterated.

Dragon's blood is in mass a brown-black, brittle resin, of no odor, and of a sweetish, afterward slightly acrid taste. It breaks with a reddish fracture, and is translucent in thin layers. It is entirely soluble in alcohol, chloroform, carbon disulphide, etc., with the exception of from ten per cent. upward of vegetable tissue and other impurities. It softens and becomes sticky by the warmth of the hand, and at a higher temperature is partly decomposed, liberating among other things benzoic acid.

It is extensively used in coloring wood stains, varnishes, etc., but has no peculiar medical properties. Its only use in pharmacy is as a harmless coloring matter for tooth powders, ointments, and similar pharmaceutical mixtures.

W. P. Bolles.

DRESSINGS, SURGICAL.—The history of surgical dressings is similar to that of drugs in one particular, namely, that their preparation has been gradually transferred from the doctor's office to a factory especially equipped for the purpose. Many articles formerly used on account of their absorbent properties, such as peat, moss, sawdust, etc., are now entirely unknown among younger surgeons. Similarly the increased use of plaster-of-Paris bandages has rendered obsolete many complicated forms of splint.

The materials at present used in surgery during operations, and for dressings, will be considered under the following heads: Sutures and Ligatures, Drains, Absorbent Materials, Bandages, Plasters, Splints, Lubricants. A brief consideration of Handkerchief Dressings, and the Application of Plaster of Paris will close the article.

Sutures and Ligatures.—Some of the materials ordinarily used for ligatures or sutures are absorbable in the tissues, and some are non-absorbable. This distinction is of the first importance in the selection of a suture or a ligature. Thus, for the suture of a broken bone or to close a ventral hernia, one would not select a material which would be absorbed in a week. On the other hand, many surgeons object to the use, even in these situations, of material which can never be absorbed.

The length of time during which different materials may be expected to withstand disintegration in the tissues of the body may be roughly stated as follows: fine catgut, from two to four days; coarse catgut, from five to seven days; animal tendon, from three to ten days. Catgut or animal tendon which has been immersed twenty-four hours in a solution of bichromate of potassium will resist disintegration for from four to six weeks. Fine or coarse silk, silkworm gut, horsehair, and silver wire will never be absorbed.

Surgical catgut is made of the small intestine of the sheep and other animals, washed to free it from dirt, soaked in ether to free it from fat, and then sterilized. For use it is preserved either dry or in alcohol, or in some antiseptic solution. It is sold in various sizes, from 00 up to 10 (Fig. 1656), though the very large sizes are seldom used.

The sterilization of raw catgut has presented many difficulties. If boiled in water it turns to jelly. Its sterilization by steam is for the same reason impracticable. If sterilized by dry heat the temperature may reach 150° C. without injury to the catgut, provided that every particle of moisture be first removed from the gut. A special apparatus is therefore required, and the sterilization by dry heat is not sufficiently certain to warrant the general adoption of this method.

If catgut is soaked in a solution of formaldehyde gas, formalin as it is called, from one to twelve hours, according to the size of the gut, the albumen will be so altered as to permit the catgut to be boiled in water for a time without injury. This method of sterilization presents the difficulty, however, that the gut must be kept tightly stretched, and that the strands shall not overlap either during the soaking in formalin or the boiling in water. Various kinds of racks have been devised to accomplish this end. One of the simplest plans is thus described by Fredrick: Wind the gut in a single layer on a glass spool, in either end of which a notch has been filed. Pass one end of the catgut through the spool and tie tightly to the other end of the catgut. Drop the spool into a three-per-cent. formaldehyde solution. Leave it in the solution a longer or shorter time, according to the size of the gut, as follows: No. 00, three hours; No. 1, three hours; No. 2, five hours; No. 3, seven hours, etc. Wash in running water, boil fifteen minutes, and keep in sterilized bottles in ninety-per-cent. alcohol containing eight per cent. glycerin. The glycerin should be sterilized by heating in a water bath before it is added to the alcohol. If a spool of catgut is partly used, tie the ends of the catgut together, drop the spool into boiling water, and place it in a sterile bottle as before. Catgut so prepared will resist absorption a week or ten days.

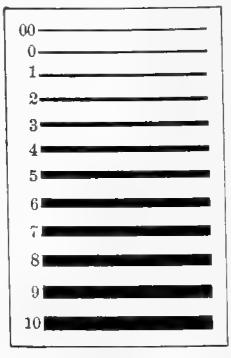

FIG. 1656.—Sizes of Ligatures.

Catgut may be sterilized by soaking it in antiseptic solutions. A great number of formulæ have been proposed. The catgut can either be used from the antiseptic solution or it can be removed from it after it has lain in it a certain number of hours, and be preserved for use in alcohol. A good example of this method is the following: Wash the catgut in ether and soak it for from one-half hour to two hours, according to the size of the gut, in ten-per-cent. solution of carbolic acid in alcohol. Keep until wanted in alcohol. The objection to this method is its uncertainty. No matter what antiseptic is employed, one can never be sure that it has penetrated the gut in every part. Moreover, some antiseptics weaken the gut, and if not removed from it they may prove injurious to the tissues of the patient.

Catgut may be sterilized by boiling in alcohol. The alcohol should not contain more than five per cent. of water, lest it weaken the gut. Ninety-five-per-cent. alcohol boils at about 79° C., and hence germs as well as spores may not be killed by this process if it is continued for only a short time. Moreover, the alcohol evaporates so rapidly that it is necessary to add fresh alcohol every few minutes. This is expensive, and the fresh, cool alcohol continually reduces the temperature and gradually increases the percentage of water. These difficulties can be avoided by using a small still (Fig. 1657).

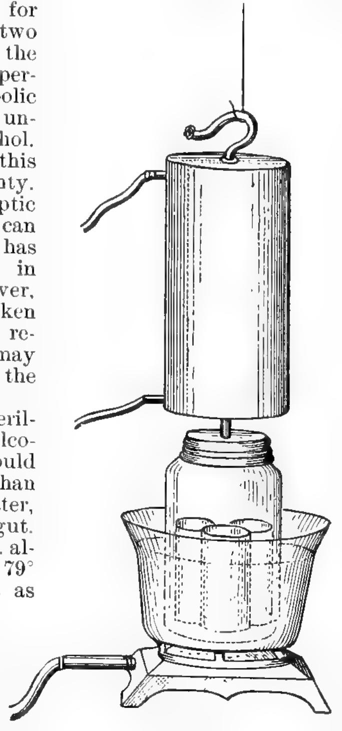
FIG. 1657.–Apparatus for Boiling Catgut in Alcohol.

With the apparatus above pictured one can prepare quickly and easily a gut which will yield good results in minor surgical work. It cannot be recommended for major surgery, however, for there is always a possibility that the ligature is not sterile.

Catgut may be boiled in alcohol under pressure. In this way a temperature of 90° C. can be maintained for one hour without injury to the gut. Gut so treated will be sterilized absolutely. Such apparatus is costly, and will scarcely be found outside of hospitals and manufactories of surgical supplies.

Catgut may be absolutely sterilized by boiling in some substance whose boiling point is high and which will not injure the gut. Oil of juniper was once much used for the purpose, but it makes the gut very springy, almost like wire, and if boiled too long the gut becomes brittle. Cumol is one of the best substances for this purpose. It is oily, boils at about 155° C., and does not injure the gut. When ligatures have been sterilized in this manner they may be placed in alcohol for use, sealed up in tubes if desired, or first placed in germ-proof envelopes when the ligatures and envelopes can be sterilized together.

The following description is interesting as showing the number of steps which are taken in the preparation of aseptic ligatures by one of the well-known manufacturers:

1. Exterior cleansing by scrubbing.
2. Removal of moisture.
3. Sealing in envelopes made of toughened filter paper.
4. Successive percolations with solvents (naphtha, ether, benzol, alcohol, etc.).
5. Sterilization by boiling in a solution of cumol compound at a temperature of from 160° to 170° C.
6. Removal of cumol solution by heat.
7. Final sealing in an aseptic outer envelope and transference to outer container.

A somewhat simpler method is followed in the Johns Hopkins Hospital, but numerous bacteriological tests have proved it absolutely reliable. The steps of the sterilization are: 1. Roll the catgut, twelve strands in a figure-of-eight form, so that it can be slipped into a large test tube. 2. Bring the catgut up to a temperature of 80° C. and keep it at that point for an hour. 3. Place the catgut in cumol which must not be above a temperature of 100° C. Then raise it to 165° C., and hold it at that point for one hour. Pour off the cumol, and allow the heat of a sand bath to dry the catgut, or dry it in an oven at a temperature of 100° C. for two hours. 5. Transfer the ring of gut with sterile forceps to a test tube previously sterilized as in the laboratory. In drying and boiling, the catgut must not touch the vessel. It is therefore suspended on wires, or rests on absorbent cotton.

FIG. 1658.–Sterilized Catgut in Bottle, Ready for Use.

To close hernial openings, and under other circumstances, a suture is needed which will resist absorption longer than plain catgut. This need led to a search through the animal kingdom for other suture material. By far the best is the tendon of the kangaroo's tail. This large, strong tendon, when dry, falls naturally into a loose bundle of separate round cords, each about the size of very heavy catgut. These naturally separate fibres are easily obtained a foot or more in length. The large tendons of the kangaroo's leg are also made up of bundles of fibres, but the separation of the individual cords is not so perfect as in the tail tendon, and the cords, or many of them, are so large as to require splitting. These split threads from the legs are not so desirable as the naturally rounded ones from the tail. Other animal tendons are split into threads and used, but they are far inferior in appearance to the ligatures made of kangaroo tendon.

These animal tendons have a varying resisting power, and the source of supply in the case of the kangaroo is limited. Hence the need of increasing the durability of catgut by chemical means. This is done by soaking the gut in a watery solution of bichromate of potassium. The strength of the solution and the number of hours the gut soaks in it form a rough means of telling how long the suture material will resist disintegration. Thus, one speaks of eight-day catgut, fourteen-day catgut, etc., meaning catgut which has been so treated that it is expected to resist disintegration for so many days. It is only fair to state that clinical results are not so uniform as the laboratory tests, and those who have had occasion to reopen wounds at the end of a few days have sometimes found that chromicized catgut intended to last several weeks has fallen to pieces in as many days.

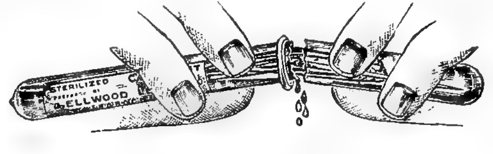

FIG. 1659.—Sterilized Catgut in Sealed Glass Tube.

A well-tried formula for making chromicized catgut is as follows: 3 parts of bichromate of potassium, and 20 parts of glycerin and carbolic acid, are dissolved in 2,000 parts of water. In this solution the gut is soaked for twenty-four hours. If it is to be subsequently sterilized by formalin, it can be wound on spools before it is put into the hardening solution. Gut so treated is expected to last six weeks in the tissues.

Silk has always been a favorite suture material on account of its flexibility, smoothness, and strength. Since the days of asepsis it has lost none of its popularity, for it may be sterilized without injury by boiling water or steam. Dry heat, if too high or too long continued, makes the silk brittle.

Small sterile threads of silk may be buried in the tissues with impunity, as is constantly illustrated by the use of silk in intestinal sutures, while some operators also use it in place of catgut for ligatures. As fine catgut can be absolutely sterilized, the use of silk for ligatures is theoretically unsound, as even the finest threads can never be absorbed but must remain as foreign bodies. Larger silk threads, even though sterile, may be harsh enough to give rise to a suppuration which continues until the silk is expelled from the body. In order to minimize such irritation, the minor strands in the larger sizes of silk are often braided instead of twisted, or are twisted loosely, giving a soft floss silk. Even then the danger of irritation and suppuration is not wholly done away with, and it is no longer considered a sound surgical practice to tie large masses of tissue with heavy non-absorbable thread if the conditions permit of the separate ligation of vessels with absorbable catgut or with fine silk. The larger sizes of silk are not dyed. The smaller ones are usually dyed black, with fast non-poisonous iron dyes, in order to facilitate the detection and removal of the sutures.

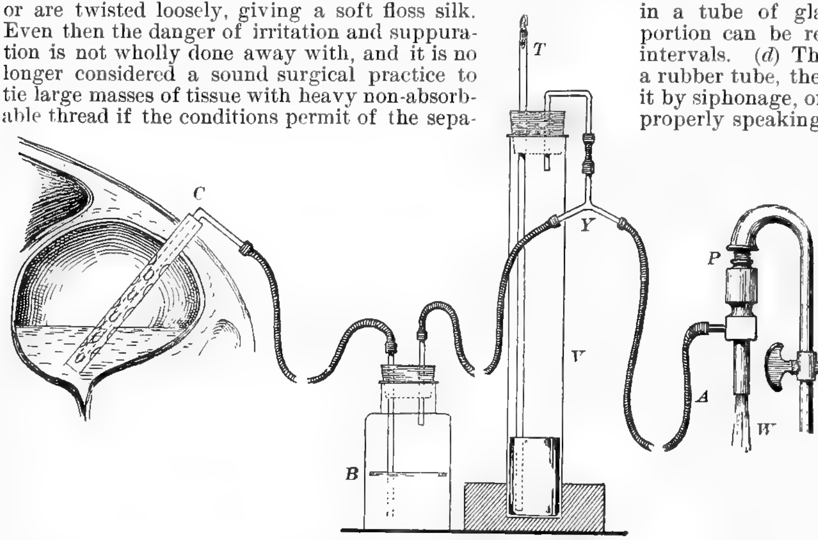

FIG. 1660.—Walker's Suction Apparatus.

Silkworm gut, or *fil de Florence*, is made by drawing out into a single thread, the fluid silk in the body of the silkworm ready to spin its cocoon. As it is in demand for fastening fish hooks to the line, it can be easily obtained in bundles of one hundred threads each, twelve or fifteen inches long. The curled brittle ends are trimmed off, and the threads are ready for use. They are smooth, strong, and springy, and occasionally they break if tied in too hard a knot. They are sterilized by boiling water or steam. On account of its polished surface silkworm gut, if the ends are not buried, is not irritating to the tissues, and the sutures are easily withdrawn. It is an excellent material for tension sutures; but its sharp ends make it a poor material for buried sutures. It may be dyed black, like silk, to make it more conspicuous.

The hair from a horse's tail resembles silkworm gut, but is not so strong nor so springy. It is a splendid material for suturing the skin if the strain on the sutures is not great. Horsehair can be sterilized by boiling.

Pure silver wire is sometimes used for suturing the abdominal wall, and often for suturing the cervix uteri. Its special attributes are absence of springiness and the fact that it can be fastened by twisting the ends about each other. Hence it can be used in a narrow vagina where it would be difficult to tie a knot. It can be sterilized by moist or dry heat without injury.

Drains.—A drain is intended to do one or more of the following things: (1) To preserve a track from the surface to a deeper part of the wound; (2) to prevent superficial parts from healing until the deeper parts have done so; (3) to favor the escape of fluid from the deeper parts of the wound, thus revealing the existence of hemorrhage and ridding the body of pus or other objectionable fluids. A properly applied drain will readily accomplish the two objects first mentioned. So would a stick or a solid rubber cord. The third object is far more difficult of attainment. It can be done in only four ways: (*a*) If the drainage is down grade, gravity will bring the fluid out through a tube or around and through a gauze drain. (*b*) If the fluid is secreted so freely that its retention would cause pressure, a part of it will escape after the wound and drain have been filled with fluid. (*c*) The drain may be used to soak up secretion, either by having it made of a mass of gauze, or by so arranging it in a tube of glass or otherwise that the central portion can be removed and replaced at frequent intervals. (*d*) The drain being a hollow one, like a rubber tube, the fluid may be sucked out through it by siphonage, or by means of a pump. This is, properly speaking, a suction apparatus rather than a drain. If fluid collects slowly it may be sucked out with a syringe every hour or so; but to keep empty the urinary or biliary bladder after cystotomy, an automatic apparatus is most useful. The best one yet offered is that recently devised by Dr. John B. Walker, of New York. It consists of a small "laboratory" suction pump *P*, which is screwed to a cold water faucet. The effect of the stream of running water, *W*, is to suck air through the tube *A*. If one-eighth-inch lead tubing is used for this purpose the cold-water hydrant may be one hundred feet or more away from the patient's bed. The tube (*A*) splits at *Y*, so that it not only sucks air from the bottle *B*, but also, in case the suction is too strong, from the safety valve *V*. The bottle is closed with a tight rubber stopper, through which the two tubes pass, one of which connects with the catheter *C* which leads into the bladder, and sucks out fluid from that viscus to the bottle as fast as it accumulates. The safety valve *V* is a simple arrangement, but is the key to the successful operation of the whole device. It is a test tube fifteen or twenty inches long, in the bottom of which are three or four inches of mercury. The tube from *Y* merely passes through the rubber cork of *V*, so as to suck out air at times. Another tube, *T*, in the upper end of which is a little cotton to keep out dust, passes through the rubber cork and extends through air and mercury to the bottom of *V*. If the catheter in the bladder sucks a bit of mucous membrane into its eye, or if the water in the pump is running too rapidly so that an undue suction is exerted on the bladder wall, air will be sucked in through *T*, will bubble up through the mercury in *V*, and escape into *A* at *Y*, thus relieving at once the strain upon the bladder wall. By changing the quantity of mercury in *V* one can easily regulate the maximum suction upon the bladder. With this apparatus one can keep a patient upon whom suprapubic cystotomy has been performed absolutely dry, while all of the urine is collected for measurement and examination if necessary.

Different materials are used for drainage, according to the emphasis laid on flexibility, capillarity, or maintenance of a fixed size. A bundle of horsehair, a wick of gauze, and a glass tube are good illustrations of the three types of drains. A bundle of horsehairs twisted together, doubled, and allowed to twist in the opposite direction and then tied, makes an excellent small drain, for example in scalp wounds, since it affords little opportunity for fibrin and granulations to cling to it and make its removal difficult.

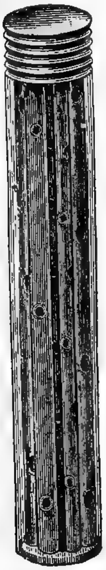

Fig. 1661.—Rubber Drainage Tubes.

Fibrin is very apt to fill up the meshes of gauze drains, especially in abdominal wounds, so that their removal is painful. They can best be removed by twisting in one direction several times, then unwinding and twisting several times in the opposite direction. Another plan is to roll the gauze before it is twisted in a small square of gutta-percha tissue as a cigarette is rolled, so that the fibrin cannot adhere to the sides of the drain. It is open at the bottom, so that whatever capillary power the gauze possesses may not be interfered with.

For draining a large cavity with gauze Mikulicz hit upon the idea of spreading a single layer of gauze like a handkerchief over the whole cavity, and packing a number of thick wicks of gauze into its cavity. These wicks can be removed and replaced, if necessary, without difficulty, as only the outside handkerchief clings to the walls of the wounds and pulls off without much trouble after all the wicks have been pulled out.

Tubular drains are made either of rubber (Fig. 1661) or of glass (Fig. 1662), and are of various shapes and sizes. There is no capillary action in tubes of this sort, and fluid will come out through them only as a result of gravity, pressure from within, or artificial suction. When a patient lies in bed his wound is apt to be upward, and there is rarely pressure within it. So the saying has become a common one that "drainage tubes do not drain." Their chief value is in keeping open a straight sinus from the surface to the depth of a wound.

Absorbent Materials.—Lint, peat, earth, and various other materials capable of absorbing discharges, have been used for dressing wounds. Oakum and rags are still used somewhat, but cotton, either loose or woven into gauze, has pretty nearly supplanted all other materials as an absorbent dressing. When the oil and impurities have been removed from it, and it has been bleached, washed, and dried, the cotton very quickly soaks up fluid. It is then in little tufts, and is sold under the name of cotton waste, for absorbing free discharges, as it costs less than carded absorbent cotton, and will soak up pretty nearly as much fluid. The carded cotton, common absorbent cotton, is a finer product, and is so universally employed for dressing aseptic and septic wounds that it needs no description. It is practically freed from germs by the process of manufacture. If re-sterilization is desired, the cotton can be steamed or baked. It is apt to become moist in a steam sterilizer, and it should either be dried artificially or exposed to the air until dry. If the latter plan is adopted, it is necessary that each package of cotton should be loosely wound and pinned up in a towel or gauze, so that when removed from the sterilizer the moisture may rapidly evaporate. Dressings should never be allowed to cool in a steam sterilizer, but should be removed while steaming hot. This applies equally to packages of gauze and cotton as well as to towels and gowns, as they are apt to remain damp a long time if they are allowed to cool in the steam cylinder.

Gauze for surgical dressings should be equally as absorbent as cotton. Indeed, its open meshes make it even more ready to soak up fluids, and it is generally used to keep a wound dry during an operation in preference to cotton, or wool, or sea sponges. The advantage of having each absorbent sponge as it is applied to the wound fresh and clean and sterile is a very great one, and few surgeons will be ready to return to the old plan of washing sea sponges during an operation, even though by a new method, which is described below, the sponges can be boiled without injury before each operation. In many operations there is an infectious discharge, which, if sea sponges are used, will be introduced into the wash-water, will spread through the rest of the sponges, and will increase the chance of a diffuse suppuration in the wound. This risk is limited if each gauze sponge applied is a clean one and is thrown away as soon as used. It may be objected that in using so large a number of sponges one may be left in the peritoneal cavity in operations upon the abdomen. This unfortunate mistake has many times been made. Sea sponges, as well as gauze sponges, and even instruments, have been sewed up in the patient's abdomen. Many plans have been devised to prevent the mistake, and although the best plan may be thwarted by carelessness of the surgeon or one of his assistants, every abdominal operator should adopt some definite plan to minimize the risk of leaving a sponge in the abdomen. Perhaps these two rules are the best: 1. Count all sponges of which only a few are used; for example, large flat sea sponges or gauze pads. 2. Use no sponge nor pad unless it is in a sponge-holder or has some metallic instrument attached to it.

Sea sponges have hitherto been sterilized by soaking them in antiseptic solutions. This method is such an uncertain one that they are ordinarily not used a second time. A far better method is one recently devised by Elsberg, of boiling the sponges in a solution of potassium hydrate 1 part, and tannic acid 2 parts, in 100 parts of water. Sponges may be boiled repeatedly in this solution without undergoing any material change. After boiling they are rinsed in sterile water and are ready for use. Sponges so sterilized are as soft and absorbent as new ones, and may be washed and boiled and used again and again until they wear out. The fluid in which they are boiled may also be used over and over again. Fresh sponges are soaked in an eight-per-cent. solution of hydrochloric acid for some hours to free them from calcareous matter. They are then boiled on three successive days for a half-hour each day, in the potash-tannic acid solution.

Bandages.—A bandage may be used for one or more of these three purposes: to keep a dressing in place; to exert pressure; to limit motion. The ironed bleached muslin bandages of the previous generation have given place to gauze ones, and with this change fine bandaging

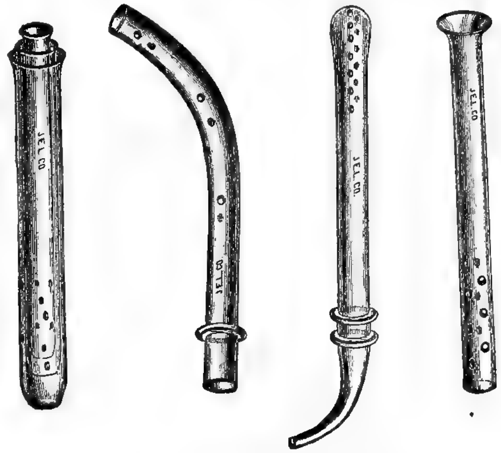

Fig. 1662.—Glass Drainage Tubes.

has wellnigh become a lost art. The gauze bandages are more easily applied, are more comfortable, and are cheaper. For rougher work, unbleached muslin is generally employed. These materials have little elasticity, and if pressure is desired, a layer of cotton, preferably non-absorbent, is spread on the part before the bandage is applied. An all-wool flannel bandage, especially if cut on the bias, has a good deal of elasticity, so that it can be applied directly to the skin and made to exert a considerable pressure without discomfort, if care is taken to make the upper and lower edges of each turn of the bandage equally tight. Such a bandage applied every morning is especially serviceable to relieve chronic œdema of the feet and legs. A double or tubular stockinette bandage is also well adapted to this purpose and for use in the treatment of chronic ulcer of the lower extremity.

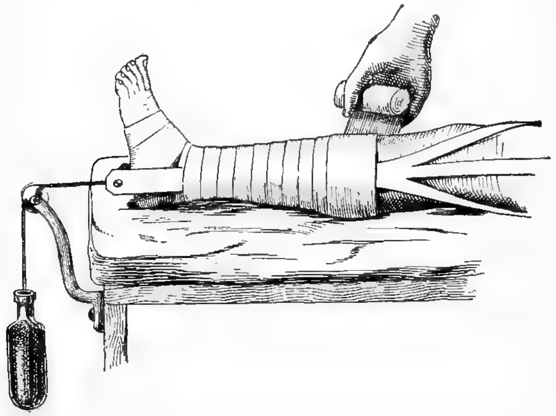

FIG. 1663.—The Use of Adhesive Plaster in Extension.

Gauze, muslin, and flannel bandages may serve to keep dressings in place or to apply pressure; but if strong pressure is desired for a short time a rubber bandage is preferable, since its great elasticity will make and keep a limb anæmic during an operation. Such a bandage is often called an Esmarch bandage, from the surgeon who so strongly advocated this method of bloodless operation. The directions for its use are as follows: elevate the limb, and then wind the bandage spirally, with a constant pressure, from the tip of the extremity to the middle of the arm or thigh. There should be no reverses nor figure-of-eight turns. Each turn should overlap its predecessor by one-half inch or less, so as to facilitate the removal of the bandage from below upward. The uppermost two or three turns should be left in place, to shut off the circulation, or a separate ligature may be applied for this purpose. The rest of the bandage is removed from below upward, and the limb will be found to be bloodless and will remain so until the ligature is loosened.

While a bandage of any sort of material may have the effect of limiting motion, this end is best achieved if some stiffening material is incorporated in the bandage or painted over it. Dextrin and soluble glass are applied on the outside of a completed muslin bandage,—starch and plaster of Paris are incorporated in a gauze bandage, which is wet immediately before it is put on. The best starch bandages are made of strips of the heaviest white crinoline, loosely rolled up. Muslin starch bandages do not wet through easily, and the turns do not lie as closely upon each other, nor adhere as well as the turns of a crinoline bandage. Crinoline is also the best basis for plaster-of-Paris bandages, as it wets more quickly, holds its shape better during its application, and presents a better appearance when applied than a plaster-of-Paris bandage made of plain gauze. It is important that the plaster be fresh so that it will set well and that the bandage be loosely rolled so that it will quickly wet through without being squeezed.

Plasters.—The three kinds of adhesive plasters in common use are the rubber adhesive plaster, the less known zinc oxide plaster, and the old diachylon plaster, now often called a "moleskin" plaster, because the adhesive is usually spread upon the smooth side of Canton flannel. Rubber plaster, as formerly made, was somewhat irritating. Now the quality of the plaster is such that irritation follows its use only upon very delicate skins. Even this slight irritating effect may be reduced if one employs, instead of the plain rubber adhesive, a rubber adhesive plaster which contains a certain amount of zinc oxide.

Moleskin plaster is chiefly used to enable the surgeon to make extension upon arm or leg (Fig. 1663). The adhesive spread upon the cloth is generally the diachylon plaster, and not a rubber adhesive. To make such plaster adhere to the skin it is necessary to heat it or to wipe its surface with chloroform.

Adhesive plaster may be so applied—either by strapping the edges together or by the ingenious method of lacing the plaster shown in the illustration (Fig. 1664)—that suturing the skin edges of a wound will not be necessary.

Plasters have long been a favorite means for the application of counter-irritants. Though ridiculed by some physicians, a cantharides or capsicum or mustard plaster will often relieve an aching back or side. One of the most efficient plasters for a sore back is a broad square of rubber adhesive plaster over which ground red pepper has been freely dusted.

Splints.—A splint should be light and rigid. If it has the third essential, the capability of being readily moulded to fit the part, it fulfils all demands. Unfortunately, no cheap material thus far found possesses these three requisites in a high degree. One has to think only of the various materials employed as splints to see that each fails in at least one of the three essentials. Wood, pasteboard, tin, iron, wire gauze, rubber, celluloid, felt, leather, and the various manufactured materials, such as wood pulp, papier maché, and cloth saturated with glue or varnish, are none of them easily moulded at a temperature which the body can bear. Plaster of Paris, freshly moistened, will fit any surface, and in a few minutes will set and dry so that it will retain its shape. But it has little strength unless in thick masses, and its weight is then prohibitive for most purposes as a splint. Hence the plaster is usually applied in the meshes of a gauze bandage, so that its rigidity may unite with the strength of the cloth, and thus avoid the great weight of a pure plaster cast. Applied in this manner plaster of Paris is easily the most satisfactory material for a rigid splint which must fit closely over irregular surfaces.

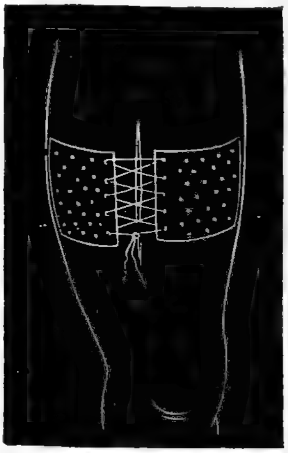

FIG. 1664.—The Use of Adhesive Plaster in Place of Sutures.

The woods ordinarily selected for splints are the softer deciduous woods, such as bass wood, soft maple, white wood, etc. They are sold in sheets of varying thickness, and the thinner ones can be made even more flexible by steaming or soaking in hot water for a few minutes. To give it an additional adaptability, a splint may be sliced lengthwise, while a strip of rubber plaster spread upon one side of it prevents the slices from falling apart. Such a splint, called a coaptation splint, is especially useful in fractures of the shaft of the humerus or femur.

Splints cut from tin with a pair of heavy shears are well adapted to holding immovable a finger or thumb in case an infected wound of a joint or tendon requires repeated cleansing and perhaps a wet dressing. Such a splint like a gutter may partly surround the finger, while it spreads out over the palm or back of the hand. When bandaged in position it fixes immovably the finger. The manufactured metallic splints which are made in the greatest variety of shapes and sizes are light and rigid, and can be bent somewhat to fit the limbs of the patient (Fig. 1665).

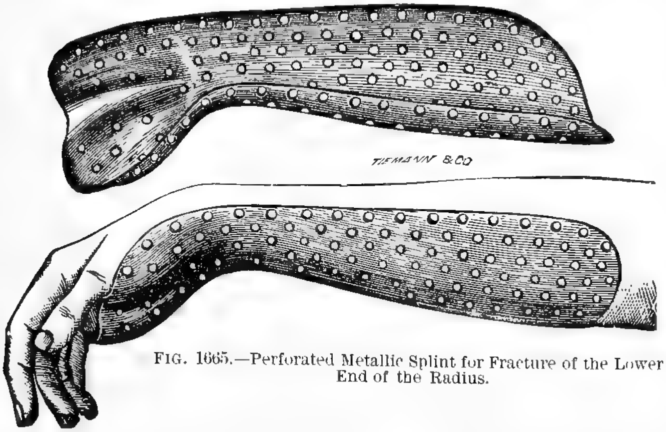

FIG. 1665.—Perforated Metallic Splint for Fracture of the Lower End of the Radius.

Splints made of felt, of leather, or of cloth saturated with glue and varnish are now seldom used. They are not sufficiently flexible when soaked in hot water to offset the disadvantages of expense and uncleanness. A fairly flexible splint material can be made of wood pulp in the centre of which is a coarse gauze to prevent the pulp from breaking. When dry this material is light and rigid. When thoroughly moistened it can be easily bent without breaking, and if bandaged in position it will when dry retain the shape given it. It will not, for example, fit an elbow bent at a right angle, and the fact that both splint and limb have to be kept in a correct position until the wood pulp dries is against its general adoption. However, such a splint, when dry, is very light and rigid, and it does not soil easily, so that a sheet of this material is a very handy thing in a doctor's office.

Every splint requires a certain amount of padding. Even if it is perfectly moulded to the limb, it will be more comfortable if it is lined with a few thicknesses of gauze or a layer of cotton. The ordinary board splints should be covered with a thick layer of cotton, which may be either bandaged on the splint or simply allowed to rest between the splint and the arm. In the latter case additional little pads of cotton can be disposed in such a manner as to fill up the hollows of the limb. Strips of adhesive plaster, two or more, are used to hold the splints in place and make pressure. The whole is covered by a bandage.

Lubricants.—The lubricants employed for the passage of urethral and rectal and other instruments, and for vaginal examinations, are usually mixtures of vaselin or lard, with antiseptic or bland substances. They are easily sterilized by heat, but they are objectionable because they are not easily removed from the surgeon, patient, or instruments. Glycerin is washed off easily since it mixes with water, but it is not a very good lubricant, and it is somewhat irritating. Soap may be used in the vagina, but not elsewhere. Preparations which are far superior to all these are those which closely resemble mucus in their physical properties. They are extremely slippery, can be diluted with water with which they mix readily, and they can be washed off as easily as a soap. One such a preparation, having as a base Irish moss, is called by the awkward name of Lubrichondrin. Like many other lubricants, it is sold sterile in collapsible tubes, so that what remains in the container does not become contaminated.

Handkerchief Dressings.—Handkerchief dressings are those in which a "triangular" or "Esmarch" bandage is employed. Such a bandage is made by folding a large handkerchief diagonally, or by cutting a piece of muslin forty inches square into two triangular halves. The name of Professor Esmarch is sometimes given to the triangular bandage because he popularized its use in Germany, in a society for giving instruction in first aid to the injured. It has been adopted by similar organizations in England and America. The triangular bandage is especially suited to emergencies, because it can be quickly torn from some part of the clothing, if a sufficiently large handkerchief is not at hand, and the methods of applying it are simple and easily learned. A roller bandage, on the other hand, is not readily improvised, its application requires considerable skill, and an ignorant person is more likely to exert injurious pressure with a roller bandage than with the looser triangular bandage.

The bandage is an isosceles right-angled triangle, the hypothenuse being called the "lower border," the right angle the "point," and the acute angles the "ends." The size of the bandage may be reduced by folding the lower border over once or twice so as to make a hem two inches wide, or the bandage may be reduced in size one-half by folding the two ends together. It may be changed in shape from a triangular to a long straight bandage by bringing the point to the centre of the lower border, and thus folding the bandage lengthwise once or twice.

The triangular bandage is applied to control hemorrhage, to hold dressings on wounds, to support different parts of the body, and to fix splints. The Society for Instruction in First Aid to the Injured of New York City, which since its incorporation in 1883 has given practical individual instruction to more than ten thousand men and women, teaches some twenty different methods of applying the bandage, the most important of which are here illustrated. (Figs. 1666–1669.)

In its triangular shape the handkerchief may be used to cover the scalp, shoulder, chest, back, hand or foot, and the hip. It may also be employed as a sling. Folded as a straight bandage, the handkerchief may be used upon the head (three positions), neck, arm, hand, waist, leg, and also as a sling and tourniquet.

To Cover the Scalp.—Fold a two-inch hem along the lower border, and lay the centre of the hem on the forehead, the point of the bandage reaching over the head to the nape of the neck. Carry the two ends above the ears and cross them at the back of the head; then bring them forward and tie or pin them together on the forehead. Carry point of bandage upward and pin at top of head.

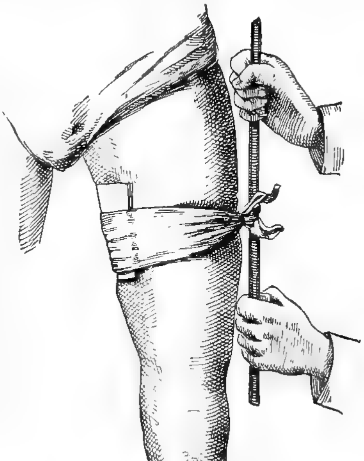

FIG. 1666.

To Cover the Shoulder.—Place the point of the bandage upward, carry the two ends around the arm and tie them together, fasten the point of the bandage under a second bandage used as a sling.

To Cover the Chest.—Place the point of the bandage upward on the shoulder of the side most affected. Tie or pin the two ends and point of the bandage at the back.

To Cover the Hip.—Place the point of the bandage upward and secure it under a second bandage folded long and used as a girdle. Tie the two ends of the triangular bandage around the thigh.

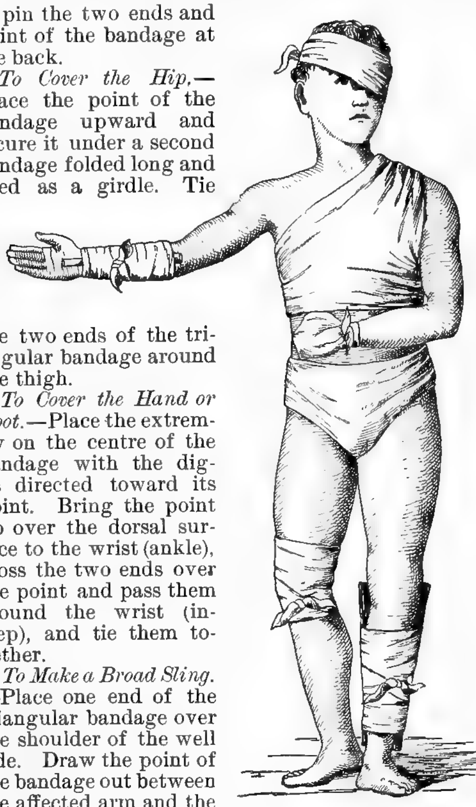

FIG. 1667.

To Cover the Hand or Foot.—Place the extremity on the centre of the bandage with the digits directed toward its point. Bring the point up over the dorsal surface to the wrist (ankle), cross the two ends over the point and pass them around the wrist (instep), and tie them together.

To Make a Broad Sling.—Place one end of the triangular bandage over the shoulder of the well side. Draw the point of the bandage out between the affected arm and the body. Carry the other end up over the injured arm and tie at the back of the neck. Draw the point around the elbow and pin to the bandage.

To Make a Narrow Sling.—Fold the handkerchief into a long strip and knot at the back of the neck. In this form of the sling, as well as in the other, the part of the sling which lies between the arm and the chest passes over the well shoulder.

To Make a Tourniquet (Fig. 1666).—Tie a folded handkerchief loosely about the arm or leg, and wind up with a short stick.

Other simpler methods of applying a folded handkerchief are shown in the illustrations (Figs. 1667, 1668, and 1669).

Application of Plaster of Paris.—Plaster of Paris is used in bulk for making impressions of any part of the body. The plaster should be of fine quality, but above all fresh so that it will set quickly. The dry plaster should be stirred into the required quantity of water until a thick paste results. This should be held for a few minutes against the part of the body of which an impression is desired. When the plaster has set it is removed as one piece, its inner surface smeared with vaseline and used as a mould, into which a freshly made plaster-of-Paris paste can be poured or pressed. In this manner an exact reproduction of the body can be made. In such a manner a model of the instep is taken for the fitting of a flat-foot brace. In order to avoid holes in the casting the outside plaster mould should be moistened before the plaster paste is poured into it.

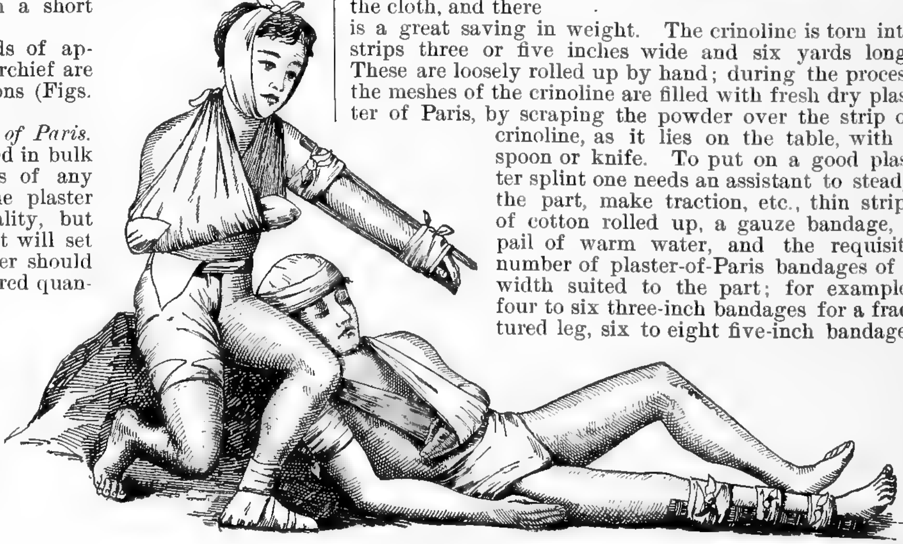

FIG. 1669.

If a mould of a round object is desired, such as the arm or the whole foot, two strings may be fastened along the limb on opposite sides with collodion, and pulled out through the plaster-of-Paris casing before that has set too hard to prevent it; or the limb may be placed horizontally in a basin and the plaster-of-Paris paste piled up around it to the middle and allowed to set. The upper surface is then smeared with vaseline and the limb is entirely covered with a new lot of paste. In this manner two separate moulds, each of which will halfway surround the limb, may be obtained. For use they may be tied together. A little vaseline rubbed over the skin facilitates the removal of the limb from the uninjured mould.

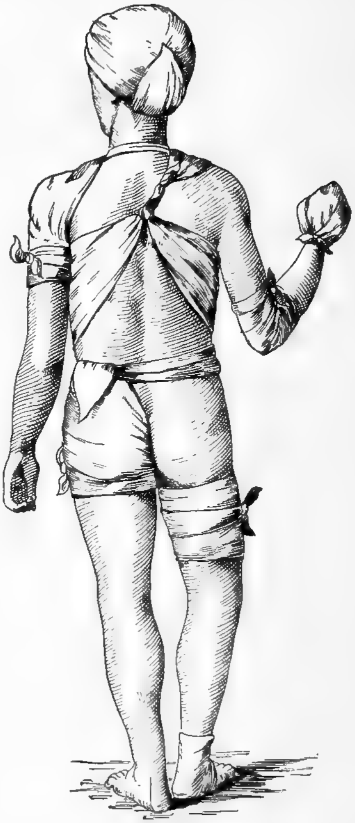

FIG. 1668.

To immobilize a limb plaster of Paris is not used alone, but is rubbed into the meshes of a gauze, or, better, crinoline bandage. In this manner the rigidity of the plaster is added to the strength of the cloth, and there is a great saving in weight. The crinoline is torn into strips three or five inches wide and six yards long. These are loosely rolled up by hand; during the process the meshes of the crinoline are filled with fresh dry plaster of Paris, by scraping the powder over the strip of crinoline, as it lies on the table, with a spoon or knife. To put on a good plaster splint one needs an assistant to steady the part, make traction, etc., thin strips of cotton rolled up, a gauze bandage, a pail of warm water, and the requisite number of plaster-of-Paris bandages of a width suited to the part; for example, four to six three-inch bandages for a fractured leg, six to eight five-inch bandages for a plaster jacket, etc. The assistant holds the limb in the correct position. The surgeon covers it entirely with the thin cotton as with a bandage. The glazed cotton batting used by dressmakers is excellent for this purpose. If absorbent or non-absorbent cotton is used, a gauze bandage is next applied so that all shall be smooth before the plaster is put on. One plaster bandage is sunk slowly into the water until it stands on end on the bottom of the pail. The water must cover its upper end. When the air bubbles have ceased to rise it is lifted out, squeezed dry with as little loss of plaster as possible, and quickly and evenly applied. The bandage should be put on regularly from the toes up. No reverses should be made, nor figure-of-eight, nor other fancy turns. Each time the bandage should ascend sharply, pass behind the limb and descend sharply, crossing the ascending turn at right angles. The slack of the distal or lower edge of the bandage should be taken up while the descending turn is being made, pressed smoothly backward, and be folded behind the limb where it will be covered in by subsequent turns. If a bandage is applied in this manner it will be perfectly smooth, have a uniform thickness throughout, and the crossing of the ascending and descending turns nearly at right angles will obviate ridges in the bandage and give it a maximum strength for the amount of material employed. As the turns are applied they should be slicked with the hand from above downward to insure their lying in close apposition so that the completed splint shall be one piece. For the same reason it is better to make each bandage cover a considerable portion of the limb, making each ascending turn an inch above the preceding one, and starting the second bandage far below where the first one ends, than it is to place each ascending turn but a fraction of an inch higher than the preceding one in order to complete the bandage as far as that particular bandage will go. When the last bandage has been applied, the whole should be rubbed down smooth with the hand or a cloth, and if a smooth surface is desired a little plaster paste can be smeared over the surface. This is of help in strengthening a weak part, and it can also be used to obscure the turns of the bandage if they have been carelessly applied.

If the bandage is to be used as a splint which can be taken on or off, it should be cut from end to end before it gets very hard, but should not be removed, or if so, should be reapplied and bandaged to the limb with a gauze bandage until it is thoroughly dry.

If the splint is intended to reach only part way around the limb, the edges may be cut away as far as desired. In this manner a light rigid splint may be secured which will exactly fit any part of the body.

Plaster-of-Paris bandages may also be used to make splints by wetting them, and running them back and forth on a table until eight or twelve thicknesses of material have been placed one on another in a long strip. Additional plaster-of-Paris paste should be rubbed into them if necessary. These are well rubbed together, and the flexible splint is applied. It can be trimmed with shears, and when properly fitted it is bandaged in position with gauze. Two such strips have been much used by Stimson in the treatment of Pott's fracture.

To remove an old plaster splint numerous saws and shears have been devised, which are for the most part unsatisfactory. Nothing is needed but a sharp knife, a little absorbent cotton, and a few drops of water. Draw the knife lightly along the line of incision, follow it with a wet cotton swab. Repeat these two steps many times. As the cut grows deeper the knife should be inclined first to the right then to the left, so as to cut out a V-shaped gutter. This will keep the knife from catching in the cut. If this plan is followed a plaster jacket can be removed with a penknife in a few minutes. A stronger knife is preferable, such as a pruning knife, but keenness of edge is more important than size. When the plaster has been cut through the underlying cotton can be easily cut with bandage scissors. *Edward Milton Foote.*

DROP FINGER. See *Hand and Fingers.*

DROPSY. See *Ascites* and *Œdema.*

DROSERACEÆ.—(*Sundew Family.*) From a biological point of view, this is one of the most interesting families of plants, owing to its carnivorous properties, as typified in the much celebrated Venus' fly-trap. Since this tendency to secrete flesh-digesting fluids is shared, to a greater or less extent, by other plants in the family, questions have been prominent as to whether they might not be utilized as digestants. The use which has been made of those species which are utilized in medicine has, however, not been chiefly in this direction, but as pectorals of an anodyne character. The species so used are of the genus *Drosera*, or sundew. To some extent they have been utilized as carminatives and gastric anodynes. The dose is 0.3 to 2 gm. (gr. v. to xxx.).

Henry H. Rusby.

DROWNING. See *Artificial Respiration.*

DROWSINESS is the manifestation of the desire for sleep, and is ordinarily shown by heaviness of the eyelids, by difficulty in keeping the attention fixed, and often by yawning. Still these indications of approaching sleep are not always present, for many persons pass almost at once from a condition of mental and physical activity into sleep, especially when in familiar surroundings, or when relieved from responsibilities which may have been long continued and sufficiently great to act as a stimulant while they lasted. Nurses and sailors furnish illustrations of this fact. The phenomena of normal or physiological drowsiness need little attention in this place, for every one is familiar with them. Siemens classes as normal the sleepiness of sucklings and children, of convalescents, of the exhausted, and of those who have been exposed to extreme cold. Still it behooves the physician to be on his guard not to confound an unusual though healthy manifestation of sleepiness with a pathological state, nor, on the other hand, to fail to recognize and distinguish the relations of a drowsiness of pathological origin. Before considering the various forms of morbid drowsiness it will be necessary to give some attention to the causes of normal sleep. This subject has long been a favorite one with physiologists, and many theories have been advanced to explain the phenomena. It would be foreign to our subject to attempt a résumé of all these efforts to explain this act of nature. In the course of the last forty years, however, an agreement seems to have been reached on certain points, such as the following, viz: 1. That a period of rest is a requisite for the healthy maintenance and normal functional activity common to all parts of the animal system, even of those the almost constant activity of which is essential to the continuance of life. Sleep affords this rest and an opportunity for regenerating the energies of the brain cells. 2. The nutrition of the nervous elements is believed by some to be favored by the less active circulation of the blood during sleep, which latter condition is now recognized as a fact, although it is not agreed whether this anæmia is to be considered a direct cause of sleep or an incident of other conditions leading to it. 3. A relation between the activity of function in other organs, such as the stomach or the skin, and the circulation in the brain has been observed and recognized too long to be ignored as being one of the conditions favoring sleep; but when we come to consider the influences attributable to changes in the composition of the blood, whether from the presence of carbon dioxide, of an excess of the normal results of digestion, or of the products of the functional activity of the brain cells themselves, we find ourselves again upon debatable ground.

With a view to presenting a summing up of the most recent and accepted views I cite from Howell, who says that sleep is required in order to recover from fatigue; that the cessation of stimuli, decreased responsiveness of the active tissues, a change in the composition of the blood, and a diminution of the blood supply to the brain are the preliminaries to sleep. He regards the fatigue of the vaso-motor centre in the bulb as the important cause of the diminished blood supply to the brain, this fatigue being caused by the continuous activity of the centre during waking hours. He also considers that the active tissues (nerve cells and muscles) as the result of their activity yield some by-product which is carried by the blood through the central system and becomes the chief cause of sleep. These views are in substantial accord with those of Lyman and Siemens. Durham quotes the following from Wilson Philip in the Philosophical Transactions, 1832: "That sleep alone is healthy from which we can be easily aroused. If our fatigue has been such as to render it more profound, it partakes of the nature of disease." Fred. J. Smith also says: "If a normal temperature is found in a man who can be easily roused, and if at the same time his pupils are active, probably nothing serious is the matter with him"; and Hammond and Da Costa also emphasize the diagnostic significance of the ability to rouse a person apparently asleep. Returning now to our proper subject of drowsiness, which in the healthy state is the precursor or the minor degree of sleep itself, we find the causes of this condition when pathological thus grouped by Dana:

"The causes of ordinary forms of drowsiness and somnolence are:

"I. Old age, when there is a weakened heart or diseased arteries with cerebral malnutrition.

"II. The diseased vascular conditions which precede cerebral hemorrhage.

"III. The cerebral malnutrition or inflammations occurring during or before certain forms of insanity.

"IV. Various toxæmiæ, *e.g.*, malarial, uræmic, cholæmic, syphilitic.

"V. Dyspepsia.

"VI. Diabetes.

"VII. Obesity.

"VIII. Insolation.

"IX. Cerebral anæmia and hyperæmia.

"X. Cerebral tumors and cranial injuries.

"XI. Exhausting diseases.

"XII. The sleeping sickness of Africa."

It will be convenient to take up the consideration of these in order:

I. *When due to the Weakened Heart or Diseased Arteries with Cerebral Malnutrition in old Age.*—This is quite in line with the views which Hammond so frequently urged, for he says: "Whatever lessens the amount of blood normally circulating through the brain tends to produce somnolence; *e.g.*, any enfeeblement, especially in the aged." Gasquet also says that "in old people drowsiness usually coexists with weak heart action and stagnation in the central and pulmonary vessels."

II. *The Diseased Vascular Conditions which Precede Cerebral Hemorrhage.*—This group of causes includes especially atheromatous and syphilitic disease of the arteries and miliary aneurisms, with perhaps the addition of impoverished or toxæmic blood resulting from degeneration or inadequacy of one or more of the emunctories.

III. *The Cerebral Malnutrition or Inflammations Occurring during or before certain Forms of Insanity.*—According to Boyer, somnolence may at such times be characterized by a special form of *sleeplessness.* He says that somnolence is an intermediate stage between sleeping and waking, which in health precedes normal sleep, but which in sickness is accompanied by cerebral excitement, and is an obstacle to sleep, with sometimes illusions and hallucinations, and leading even to a condition of sub-delirium before sleep is finally attained, these features not being recalled by the patient on waking. Siemens also notes drowsiness as often occurring in the beginning and sometimes in the course of dementia paralytica.

IV. *Various Toxæmiæ, e.g., Malarial, Uræmic, Cholæmic, and Syphilitic.*—In regard to these causes of drowsiness we may quote from Gasquet as follows: "Sleepiness is produced by the retention in the blood of certain products of tissue change, and the active agent is very probably CO_2." Conner also lays it down that there is poisoning by CO_2 in conditions of dyspnœa, uræmia, etc. Whatever the poison may be of which we recognize the effects in what we call uræmia, as a cause of drowsiness, Da Costa declares that the strong point in diagnosis is that the coma is preceded by convulsions. The pupils are apt to be dilated and react slowly to light, while Fred. J. Smith says the pulse is likely to be small and rapid. Conner also considers that "in icterus the toxæmia is due to the failure of the action of the bile as a digestive secretion and to the reabsorption of the bile into the blood through the lymph vessels of the liver." The drowsiness in icterus, according to Gilbert and Castaigne, is due to cholæmia on the one hand, and to a nervous predisposition on the other. Da Costa and Osler refer to somnolence as a feature of acromegaly, but do not point out its probable cause.

V. *Dyspepsia.*—In its severer forms, disordered and delayed digestion, especially when painful, tends to interfere with sleep rather than promote it, and the same is true of hunger. When, however, the stomach, especially after one has undergone much bodily fatigue, receives a large quantity of food, this determines an access of blood to the digestive organs to secure their functional activity, and the brain is left relatively anæmic. This explains the after-dinner nap of well-fed people on Hammond's theory that sleep is always *due* to cerebral anæmia, while Brunton suggests that the lassitude and drowsiness, so apt to follow a full meal, may be properly regarded as a mild form of auto-intoxication due to the absorption of an excess of the normal digestive products.

VI. *Diabetes.*—It would be foreign to our subject to enter into a full consideration of diabetic coma. In many of these cases its development is either very sudden or is preceded by symptoms referable to the stomach or lungs or by headache, delirium, and difficulty of breathing. In some, however, as laid down by Tirard, it may be preceded by weakness, fainting, and somnolence, coma gradually supervening. Da Costa emphasizes the rapid weak pulse and the absence of palsies as characteristic of the disease, the diagnosis being confirmed by examination of the urine. The odor of apples in the breath is also often distinctive. Osler considers that we have not yet the data for a rational explanation of the symptoms, but quotes with approval the theory of Stadelmann, Külz, and Minkowski that β-oxybutyric acid is the exciting cause of the coma. "It is a decomposition product resulting from disintegration of the tissue albumins."

VII. *Obesity.*—The occurrence of drowsiness in the obese may be explained on several grounds: by the overloading of the blood current, by an excess of the products of an imperfect digestion, by cerebral inactivity which is apt to belong to such persons, and by relative feebleness of the heart and dilatation of the abdominal arterioles.

VIII. *Insolation.*—Drowsiness can hardly be called a common symptom in heat exhaustion, this condition being often marked by depression, restlessness, and even delirium, while in true sunstroke we have unconsciousness, it is true, but speedily passing into a coma.

IX., X., and XI. The states of drowsiness attributable to these causes, viz., *cerebral anæmia and hyperæmia, cerebral tumors and cranial injuries,* also *exhausting diseases,* may well be grouped together. A condition of cerebral anæmia is assigned by writers as the direct cause of drowsiness arising under various conditions and in different parts of the system. Sometimes cerebral tumors and cranial injuries will, by pressure or otherwise, so disorder the local circulation as to cause a hyperæmia in one part of the encephalon and an anæmia in another. Sometimes the blood contains an excess of carbon dioxide or other poisonous constituents which act as narcotics, and at other times it is rendered degenerate by excessive hemorrhages or by chlorosis (Gueneau de Mussy, quoted by Boyer), so that practically an anæmia is produced. Thus Gasquet argues "whether the blood sent to the brain be diminished in quantity or contains an excess of CO_2, the supply of new material and the removal of that already used would alike be impeded. This is seen in the drowsiness following healthful exertion, if not extreme." He explains, on the theory of a direct spasm of intracranial arterioles or of a dilatation of vessels in other parts of the body, thus leaving those of the head relatively empty, the drowsiness with sleeplessness of hysterical subjects and of some cases of insanity, as well as the drowsiness following exposure to extreme cold and that observable in the idle and aimless, whose brains are ever inactive. I may also quote in support of the same view the following from Germain Sée: "The fatigue and somnolence which precede sleep are an instinctive warning of a conservative character against the danger of overdoing." It is to be noted, however, that there is not entire agreement among writers as to the etiology of this morbid drowsiness any more than we found to be the case in regard to normal sleepiness. Thus Dana says: "Most cases of morbid somnolence are closely related to the epileptic or hysterical diathesis." Also under the name of *cataphora* or *sopor*, Boyer describes "a morbid sleep which differs from true sleep in that it does not answer to the need of sleep. It is observed under the same conditions as coma, when the causes are less intense. Fevers, poisonings, large losses of blood, and nervous exhaustion also lead to cataphora."

XII. *The Sleeping Sickness of Africa.*—The morbid entity or entities included under this title exist not only on the West coast of Africa, where they were first observed, but have been observed in the French island of Martinique, in Cuba, in New South Wales, and even in Paris (Guérin) in a few instances, but only among negroes of African birth. The characteristic features are that the disease attacks negroes, that there is a progressive somnolence, with emaciation and a fatal termination. There are a marked ptosis, puffiness of the face, and enlargement of the glands of the neck, together with muscular tremor and an absence of fever, the patient having a sense of coldness even when lying in the sun. Evidently the symptoms of other diseases, such as meningitis, typhoid fever, and certain skin affections have been confounded with those of this disease in some reported cases. Its etiology remains unsettled. Da Costa and others consider it to resemble beri-beri, while Manson, regarding it as a filariasis, ascribes it to *Filaria perstans.* He refers to a case believed to have been cured by the use of arsenic. As a prophylactic, he urges care about the drinking-water.

Besides cases which would be readily referred to one of the classes enumerated above, the writers in the medical journals are constantly giving histories of unexplained or unclassified cases in which drowsiness or increasing somnolence is the most prominent symptom. Many such are associated with chorea, hysteria, or hystero-epilepsy, others with severe neuralgias, with malarial poisoning, or follow upon exhausting illness or hemorrhages. Thus William T. Gairdner tells of a girl suffering from chorea, suspended during sleep, who had a peculiar somnolence together with normal sleep. She was intelligent and generally healthy. The abnormal sleep occurred suddenly and was interrupted only by calling her name loudly, when she at once awoke and went on with what she had been doing. L. N. Sharp reports the case of an old woman of eighty-two, who after the supposed passage of gall-stones, slept for nearly three weeks, being gradually more easily aroused and sleeping less and less till she finally recovered strength and appetite.

Morison cites a case in which deep and unexplained drowsiness set in, accompanied by cyanosis. There was subnormal temperature with a weak and flabby heart, without abnormal sounds. Albuminuria one-twelfth. The patient became extremely feeble so that he could not walk, but was cured in three weeks by daily massage, after digitalis, tonics, purgatives, and corrected diet had failed.

R. Caton tells of increasing somnolence in a man otherwise healthy except for some psoriasis. He improved under out-of-door farm work with a restricted diet and intestinal antiseptics. The diagnosis was that his trouble was due to auto-infection.

R. Matas reports persistent tendency to sleep in a young woman with a malignant tumor of the brain, which gradually caused anæmia by its increasing pressure upon the cerebral mass; also a case of cervico-dorsal neuralgia accompanied by stupor, which finally yielded to tonics and anodynes.

Finkler writes in "Allbutt's System of Medicine" that somnolence, sometimes increasing to coma, is occasionally observed in the beginning or course of influenza. The clinical picture resembles cerebro-spinal meningitis that has not fully developed. It is always accompanied by fever, which distinguishes it from the coma of diabetes.

After directing attention to these various systemic causes of pathological drowsiness, we must not overlook such as are certainly very common, but not on that account to be forgotten, viz., the various narcotic drugs, most of which are in daily use. Do not fail to come to the rescue of the drowsy and half-starved baby whose wet-nurse is masking her own deficiencies with frequent doses of soothing syrup or paregoric administered to her charge, nor to refer to their proper cause the apathy, the coated tongue, and the eruptive skin of the anæmic woman whose friend has recommended "a little bromide" to help her to sleep. The *drunken* man may be very drowsy, he may also be apoplectic or have a fractured skull, so that finding an alcoholic smell about his breath does not complete the diagnosis, as many an ambulance surgeon has realized to his cost. Da Costa points out that he is likely to have a frequent pulse, usually dilated pupils, injected conjunctivæ with no lateral deviation of the eye, and that there is often violent struggling. In *opium* poisoning, on the contrary, there are contracted pupils, calm, slow breathing, the drowsiness tending to pass into coma. In this class of possible causes of drowsiness should also be remembered *chloral*, which gives a flushed face with weak and intermittent heart action, while *chloroform*, *hydrocyanic acid*, and *nitrobenzol* all give a characteristic odor to the breath, the first also a quick and tumultuous heart action, such as accompanies stertorous breathing, muscular relaxation, and anæsthesia. *Hydrocyanic acid* poisoning, when not immediately fatal, is said to produce a peculiar disturbance of breathing, with short inspiration and prolonged and labored expiration. It seems hardly necessary to do more than mention, as drugs that may be responsible for drowsiness, *cannabis indica* with its hallucinations, its exaltation, and its abolition of the sense of distance and of time, *hyoscyamus*, with its dryness of throat and dilated pupils, and the many new drugs, such as *sulphonal*, *paraldehyde*, *hydrate of amylene*, and *chloralamide.*

Under the head of *treatment* it seems necessary to enter but little into details, for this condition which we have been considering is in most instances but a symptom of some pathological state, the diagnosis of which will point the way to its treatment. In the case of *diabetes*, however, the onset is sometimes so sudden and the danger from coma so great that the threatening drowsiness should be energetically dealt with, and Tirard mentions the methods based upon the theory of attempting to oxidize the products which might otherwise form diacetic or oxybutyric acid. With this object the inhalation of oxygen has been employed; also ozone dissolved in water with the addition of 2.5 per cent. of sodium hypophosphite, or a solution of hydrogen peroxide may be given internally. The intravenous injection of hot normal salt solution, however, he thinks the most hopeful, on the theory that the solution helps to dilute the toxic agent in the blood. In the hysterical sleeping girls various authors report success from the use of tartar emetic, while Dana warns us that in some cases, as in a neurasthenic patient of his own, food had to be given through the stomach tube. In the anæmic we must make use of arsenic, of iron, of moderate open-air exercise, perhaps of stimulants, and, in cases in which the heart is weak, of diuretics, including digitalis, and perhaps purgatives. Gasquet gives the caution that "in drowsiness from cerebral tumor or thrombosis it is doubtful if we should attempt to relieve it by medicine. Probably it prolongs life by giving rest to the diseased organ, and it would be rash to act by drugs on diseased vessels."

J. Haven Emerson.

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DRUG HABITS. See *Cocaine*, *Opium*, *Chloral*, and *Insanity*.

DUBLIN, N. H.—The most elevated village in New Hampshire (between 1,500 and 1,600 feet), is situated in the southwestern part of the State, 85 miles from Boston. Although not in the White Mountain district, Dublin has a greater elevation than any resort in that region, Bethlehem being the highest with an elevation of 1,459 feet. The town lies at the base of Mount Monadnock, 3,186 feet, near which is Lake Monadnock, and possesses unusual beauty of scenery. The roads, which are good, afford charming drives. The characteristics of the climate are the purity of the air and its tonic qualities. Below are the meteorological data so far as they are obtainable:

METEOROLOGICAL DATA OF DUBLIN, NEW HAMPSHIRE.

(Temperatures in Fahrenheit scale.)

1893.	Maximum.	Minimum.	Mean of maximum and minimum.	Clear days.	Partly cloudy.
January	45°	− 14°	15.5°	13	3
February	45	− 10	17.5	13	5
March	53	1	27.0	11	9
April	61	17	39.0	12	5
May	85	32	58.5	14	5
June	86	44	75.0	10	7
July	84	46	65.0	18	9
August	86	47	66.5	16	9
September	72	37	54.5	12	6
October	70	23	46.5	10	3
November	58	11	34.5	10	5
December	51	− 8	21.5	12	7

There is no record of relative humidity, but it probably does not differ very much from that of Bethlehem, which for July, August, and the first half of September for five years was 65.8 per cent. There are frequent strong west winds, but fogs are rare.

The usual summer range of temperature is from 68° to 75° F.; the maximum, exceeding 80°, is reached perhaps once or twice in the summer. The nights are always cool. The dryness of the air is marked.

There is one first-class hotel, and there are several boarding-houses, though the predominant mode of life is the cottage one; and comfortable, even luxurious houses can be rented. There are Unitarian and Episcopal churches, also a good public library. Dublin has now become an established summer resort, and possesses many fine private residences.

The attractions are the charming excursions in the country about, mountain climbing, driving, boating, bathing, fishing, tennis, golf, and the usual social life of a large summer community. The water supply is excellent and the drainage good. The soil is sufficiently porous to absorb quickly the water after rain. The subsoil is a mixture of clay and gravel. From its elevation, from the purity and dryness of the air as well as its tonic qualities, the climate of Dublin is a favorable one for pulmonary tuberculosis. The climate is recommended also for bronchitis, gout, rheumatism, neurasthenia, insomnia, cardiac indolence, and general depression of health. From personal experience the writer can testify to the purity and exhilarating quality of the air and the beauty and charm of the scenery. In the early autumn, when the leaves are coloring and the air is crisp, outdoor life is a delight, and riding or walking along country roads affords a constant succession of delightful views.

Edward O. Otis.

DUBOISIA.—The leaves of *Duboisia myoporoides* R. Br. (fam. *Solanaceæ*). This is a large shrub or small tree of Australia and some neighboring islands. As the drug occurs in commerce, it is usually broken up into a mass of fragments, mostly from an eighth to a half-inch in length. These are brownish, smooth, and slightly shining. When entire, the leaves are from three to four inches in length by from half an inch to one inch in breadth, and are lanceolate, narrowed toward both ends, and have an entire margin. They have a very slight narcotic odor and a bitter taste. They are not very largely used, but there is a small steady demand for them, for the same uses as those of stramonium or belladonna. The alkaloids are accompanied by some resinous matter, and the accounts of them have been very contradictory. It is now generally recognized that "*duboisine*," the principal one, is identical with *hyoscyamine* in composition and action. It has been used as a substitute for atropine in eye practice, and the drug is the equivalent, in action, use, and dosage, of belladonna.

D. Hopwoodii von Mueller, or "pituri," of Australia, contains an alkaloid, *piturine* ($C_{12}H_{16}N_2$), closely resembling nicotine. The powdered leaf is smoked like tobacco, and is said to be stimulating and supporting, like coca, kola, and other drugs. *Henry H. Rusby.*

DULCAMARA. See *Bittersweet.*

DULCIN ($C_6H_4NH_2.CO.NH.OC_2H_5$).—Sucrol, Valzin, Paraphenetol carbamide, Para-ethoxy-phenyl urea. It may be made from paraphenetidin by the action of potassium cyanate, but preferably by acting upon paraphenetidin with phosgene dissolved in toluol, the product being treated with ammonia. It occurs in colorless, shining needles soluble in 800 parts of cold water, 55 of boiling water, 25 of alcohol, and freely in ether. Having about two hundred times the sweetening power of cane sugar, Riedel employs it to replace the latter in the diet of diabetics. It is also used to sweeten bitter or otherwise unpleasant pharmaceutical preparations.

W. A. Bastedo.

DUNCAN SPRINGS.—Mendocino County, California.

POST-OFFICE.—Hopland. Hotel and cottages.

ACCESS.—Viâ San Francisco and Northern Pacific Railroad to Hopland station.

The new hotel is located on a picturesque knoll, half a mile from the station. The springs are found on a hill 250 feet above the valley and 1,000 feet above the sea level. The surrounding country is of a rough, broken character, and the climate salubrious. The flow of water from the principal spring, the Duncan, is one gallon and a half per minute. There are several other springs, known as the "Seltzer," the "Iron," the "Borax," and the "Sulphur" springs, their names indicating in a general way their character. The following analysis by A. W. Thatcher shows the mineral ingredients of the principal spring:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium bicarbonate	90.11
Magnesium chloride	1.41
Magnesium sulphate	1.64
Calcium bicarbonate	15.64
Silica	6.94
Potassium bicarbonate	2.37
Sodium bicarbonate	
Total solids,	118.11

Free carbonic acid gas, 36.57 cubic inches.

The waters are said to be much sought after in the treatment of rheumatism, dyspepsia, and constipation.

James K. Crook.

DUODENO-CHOLECYSTOSTOMY. See *Gall-Bladder.*

DUPUYTREN'S CONTRACTION. See *Hand and Fingers.*

DYNAMOMETER.—The word dynamometer, derived from δύναμις, force, strength, and μέτρον, a measure, is used to denote an instrument for measuring strength or force. This may be either mechanical, muscular, or even physical. As applied to medical science, however, dynamometers are used chiefly in two ways: (1) To determine and regulate the strength of forces applied to the human body; (2) to measure the amount of strength or force which can be exerted by the human body, or various portions thereof, under various conditions. More particularly are these instruments used to determine the force of contraction of certain muscles, or groups of muscles, as the flexors of the fingers and thumb in measuring the force of the grasp of the hand, or of the muscles concerned in pushing or pulling in different ways. Less commonly they are susceptible of employment in determining resistances in which not only the muscles but the firmer and more solid parts of the organism are involved.

The earliest direct attempt to estimate the human strength for scientific purposes seems to have been made by De La Hire, who in 1699 published his "Examen de la Force de l'Homme," in the "Memoirs of the Academy of Sciences" at Paris. He determined the strength of men from their ability to lift weights and carry burdens, and compared it with that of horses.

The first instrument, however, which was directly used for this purpose, and to which the name of dynamometer was given, was invented by an Englishman named Graham; but it did not obtain notoriety until attention was drawn to it by Desaguliers, who in 1719 published his work on "Experimental Philosophy." The latter was a Frenchman by birth, but came early to England, and was made professor at the University of Oxford. He modified Graham's machine in various ways, and thus produced a machine of his own.

His machine, or rather machines, because different ones were required to test different muscles, consisted practically of a large wooden frame and stout uprights to afford points of support or resistance, and handles attached to a crossbar which moved a steelyard. By hanging weights on the latter the force used could be directly determined. Desaguliers decided from his investigations that five Englishmen were equal in strength to a horse, while it required seven Frenchmen or Dutchmen to furnish the same force.

These instruments were, however, too unwieldy and cumbersome to be used outside of the laboratory, and being also somewhat expensive they fell rapidly into disuse and were forgotten. Meanwhile Leroy, like De La Hire, a member of the French Academy of Sciences, proposed an instrument which consisted simply of a metallic tube, within which was placed a spiral spring with an attached graduated rod terminating above in a globe. This was to be grasped by the hand, and the spring compressed from above, the amount of force exerted being marked on the rod.

In 1807 Régnier first described his dynamometer. This consisted principally of an elliptic spring of metal, to which was attached a dial furnished with two rows of figures and with two hands, one for each row. The dial was so arranged that the hands were moved by any change in the form of the spring, and the force of either tension or pressure could be easily measured. The two rows of figures corresponded to the effects produced by action on the instrument according as the force was applied in the direction of the long or in that of the short axis; the upper row in myriagrams corresponding to the former, the lower row in kilograms to the latter. This instrument was the first dynamometer of practical value, and most of those in present use are more or less varying modifications of the same type. As may easily be understood, it served not only to measure force as connected with the human frame, but also the strength of machines, and the forces exerted or applied by them. It was first employed in surgery by Sédillot about 1836. He used it to determine and regulate the amount of force exerted in reducing dislocations and in other surgical operations. For this purpose the instrument was attached to one of the cords which extended from the pulley to the limb of the patient, and the measure of the force exerted was read from the dial. Sédillot used the dynamometer of Régnier, but the needles worked in a somewhat different manner. Instead of serving to mark the result of forces according as they were applied in the direction of the long or of the short axis, in this instrument one of the needles simply marked the *maximum* variation, while the other was freely movable and corresponded in position with the amount of the traction at each given moment, thus enabling the operator to recognize variations and to provide for continuous steady action. "He thus succeeded in producing continued extensions, that is to say, those maintained at the same strength and gradually and regularly increased."

None of the dynamometers thus far used appear, however, to have been simple or readily capable of application to medical purposes. In 1859 Burq first published his description of a new *pocket* dynamometer, "formed of the metals most active in metallotherapy." This was to serve, first, for the ready exploration of the strength of pressure and of traction in all the muscular systems of external life; secondly, for the closely approximative determination of the forces which the surgeon may be called upon to use, as in the reduction of certain dislocations; thirdly, for the more usual metallotherapeutic investigations.

Burq's dynamometer (see Fig. 1670) consists simply of a small box or case of metal, rectangular and open in front. Its upper and lower portions are, when it is not in use, maintained at a slight distance from the point of complete closure by a double spring of steel, which is so placed in the interior as to be always perfectly protected. This records accurately, on a dial placed in the centre of the case, the force of all efforts which may be made, directly or indirectly, with the hands or the feet, to close the case. When it is desired to test the force of traction, the hooks represented in the figure are inserted into openings made for them in the top and bottom of the case, and the traction is exerted by means of the handles which are attached to them below.

Another important modification in the form of dynamometers was that introduced by Duchenne, of Boulogne, and apparently first described in 1863. A little later he speaks of it thus: "I have had made a powerful dynamometer (measuring from 1 to 100 kgm.), and a sensitive dynamometer (measuring from 1 to 8 kgm.). The powerful one serves to measure the force of the pressure of the closed hand, that of all movements of parts, and the amount of what I have called nervous excitability (*irritabilité nerveuse*), or the degree of exhaustion of this excitability. First, we measure the force of pressure of the closed hand by placing in the palm of the hand, between the thenar eminence and the second phalanges of the flexed fingers, the handles of the dynamometer *crossed.* Secondly, it is designed to measure the force of the movements of parts. Then its handles should be uncrossed. For example, if we desire to measure the force of the movement of flexion of the lower arm, we fasten something to the end of it (a handkerchief folded crossways or a strap), to which we can attach the handle of one of the branches; then, while the subject holds the forearm powerfully flexed, the operator seizes the handle of the free branch and pulls on it until the forearm begins to extend. The sensitive dynamometer, of a form analogous to the preceding, is designed to measure in grams the force of partial movements in persons who suffer from paresis. Thirdly, the movable needles are designed to measure the force of the nervous excitability.

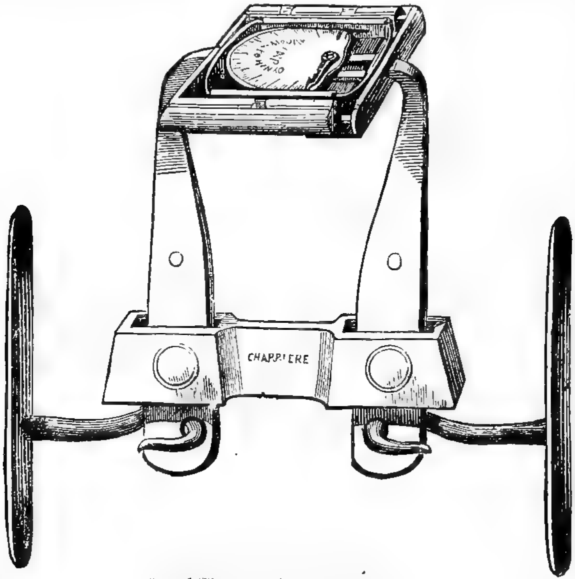

FIG. 1670.—Burq's Dynamometer.

The instrument (see Fig. 1671) is composed of: (1) A powerful spiral spring, which ends in two straight branches (*O*, *O*) placed side by side and parallel—the spring is made tense by the separation of these branches; (2) two handles (*P*, *P*), which are fixed at will either at the extremity of the branches or near their central point, and by means of which the branches can be separated; (3) a plate (*C*), placed on the anterior face of the spring, and on which are engraved two rows of numbers (*A*, *B*), marking in the first from 1 to 100 kgm., in the second from 1 to 40; (4) a needle (*D*), which is set in movement by the separation of the branches, and marks the amount of force which causes this separation.

Dönhoff's myodynamometer was designed to "determine with mathematical exactness the degree of muscular power in disease." The instrument acts on the lever principle. A bar fifty-five inches long, with a notch five inches from one end, is so placed that the notch fits into the corner of a prism-shaped support on which the bar can be moved as a lever. The long arm of the lever contains fifty notches an inch apart, and on any of these a ten-pound weight can be suspended. The beam itself can be held in equilibrium by a two-pound weight fastened to the end of the short arm. In order to use the instrument it should, if possible, be placed on a table near which the patient sits. He presses with his right hand on the short arm of the lever, while the physician places the weight so as to neutralize the pressure. The limit of the muscular power stands at that point at which the patient is no longer able to keep down the short arm of the lever.

Among dynamometers for special purposes mention should be made of Mallez' vesical dynamometer, intended to measure the muscular force of the bladder. It is composed of the following parts: (1) A tube 0.04 mm. long, and 0.01 mm. in diameter; (2) a little cap, which forms one of the extremities of the tube, extends into it, where it moves up and down with slight friction, and receives the shock of the column of liquid; (3) the cap is surmounted by a rod, surrounded by a spiral spring of known resistance, and this rod extends a certain distance beyond the farther extremity of the tube; (4) a pin placed on the rod at its exit from the tube is in contact with the shaft of a needle, and communicates to it the upward movements of the rod. The divisions of the dial over which the needle plays indicates the degrees of impulse, and the point of stoppage shows the measure of the greatest force developed.

All the instruments hitherto described are more or less complicated or designed for special purposes, and they are not much used at the present time. On the other hand, their place is supplied by simpler and less costly instruments. Mathieu's dynamometer, which is now in general use, is a modification of Régnier's, in which the dial, instead of projecting beyond the spring, is placed between its branches, making the instrument smaller and easier to handle. As it is intended only for medical use, the spring need be only of a moderate resistance. The dynamometer of Robert and Collin is practically the same as that of Mathieu (see Fig. 1672).

Dr. Græme Hammond, objecting to the fact that the hand of the patient sometimes covers the dial plate in Mathieu's instrument, so that the steadiness of the muscular contractions cannot readily be perceived, has, in his form, placed the dial plate at one extremity of the ellipse instead of on the side, as does Régnier. In his instrument the dial plate has the double rows of figures, which should be used on all dynamometers, and, the plate being larger and the hands longer than in the ordinary form, smaller degrees of pressure can be registered.

Hamilton's dynamometer consists of a graduated glass tube which dips into a rubber bulb. This bulb is filled with colored water, which rises in the tube when the bulb is compressed. Hamilton thinks that the rubber bulb is better adapted to receive pressure exerted by all

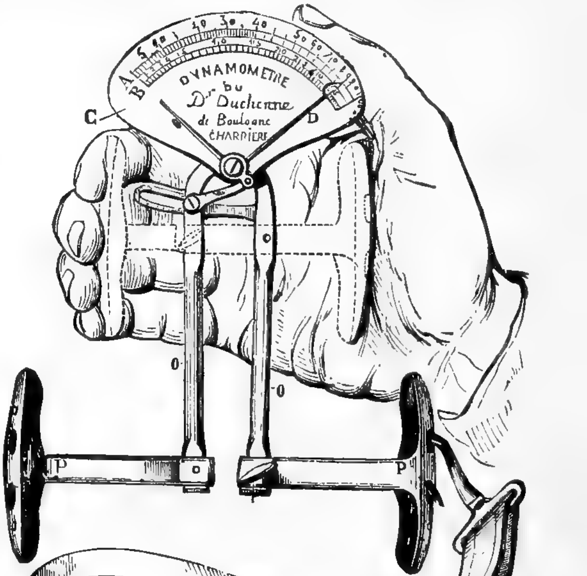

FIG. 1671.—Duchenne's Dynamometer.

the flexors of the hand than is the spring dynamometer, which is acted on by only some of them.

The uses of the dynamometer, from a medical point of view, have already been indicated. In disease it is used frequently to determine the amount of muscular force in muscles or series of muscles, either by comparison of those on the one side with the corresponding ones on the opposite side, or by comparison with the standard of health. It is of greatest value in cases of partial paralysis, in which it is desirable to test more or less accurately the strength of special muscles. In this way it is used as a means both of diagnosis and of prognosis. In health, also, the dynamometer has been frequently used: 1. To determine the average power which the human body can exert during a given time. Thus has been calculated the average amount of labor of various kinds which can be performed in a day. 2. As a method of selection for special duties.

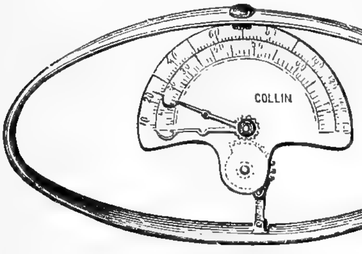

FIG. 1672.—Dynamometer of Collin.

In regard to the muscular power of men as determined by the force of the hand grasp, Rey gives the following table, which he obtained from the examination of seamen in the French navy or applicants for the service:

REY'S TABLE.

Number of subjects observed.	Ages.	Mean muscular power in kilograms.	Number of subjects observed.	Ages.	Mean muscular power in kilograms.
1	10.5	20.00	2	21.5	40.00
1	12.0	15.00	10	22.0	43.20
2	14.5	21.50	1	22.5	45.00
2	15.0	27.50	8	23.0	39.75
1	15.5	22.00	2	23.5	41.00
8	16.0	32.00	4	24.0	42.75
4	16.5	37.75	2	25.0	37.50
41	17.0	36.92	1	25.5	46.00
29	17.5	35.82	1	26.0	40.00
47	18.0	34.72	1	26.5	44.00
17	18.5	38.94	3	27.0	44.00
41	19.0	38.80	1	27.5	40.00
2	19.5	40.00	1	28.0	35.00
36	20.0	40.61	4	29.0	37.25
23	20.5	40.14	2	30.0	45.00
51	21.0	40.70	1	36.0	42.00

Mean between ages of 10 and 20 .... 31.54 kgm.
" " " 15 " 20 .... 35.75 "
" " " 20 " 25 .... 41.11 "
" " " 20 " 30 .... 41.25 "
" " " 25 " 30 .... 41.40 "

Mathieu's dynamometer was used. The subject standing firmly, seized the instrument in the palm of his hand, and was asked to exercise progressively the strongest pressure of which he was capable. Rey concludes that the mean muscular power of a man 19.5 years old, as measured in this way, equals 38.17 kgm. Michéa quotes Maréchal to the effect that 28 kgm. is the maximum effort that a cannonier should use to execute a manœuvre, and 21 kgm. the mean. He states that in good health a man has a power of pressure equal to 50 kgm., and a force of prehension equal to 132 kgm. A woman has about two-thirds that of a man.

The average daily work of men has been carefully determined in various ways. A table giving the results obtained may be found in the ninth edition of the "Encyclopædia Britannica," article "Mechanics."

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DYSCRASIA. See *Diathesis.*

DYSENTERY.—HISTORY.—Dysentery was one of the best known of the diseases of the ancient world. It was noticed before the time of Hippocrates (430 B.C.), but this writer was the first to give an accurate description of its symptoms. He clearly differentiates it from diarrhœa, as the following extracts from his works show: "But when the body being heated, acrid matters are discharged, the intestine is excoriated, ulcerated, and the stools are bloody; this is dysentery, a grave and dangerous disease." "When there is dysentery, pain occupies the whole abdomen; bile, phlegm, and heated blood are discharged." From the time of Hippocrates to that of Celsus (25 B.C.–45 A.D.), the contention of schools and theorists did but little to advance medical knowledge, but the writings of the medical Cicero, as Celsus has been called, may be said to epitomize the learning and practice of his predecessors, and that the chief features of dysentery were then understood, this quotation from his works well illustrates: "The next disease of the intestines is usually called tormina; in the Greek language it is termed dysenteria. The intestines are ulcerated internally; grumous evacuations come from them; sometimes the excretions are mixed with fæcal matter always liquid, at other times the discharges are slimy; sometimes particles like flesh pass with them: there is a frequent desire of going to stool, with pain in the anus; with this pain a small portion is voided, and even by this the pain is augmented; that is relieved after some time, and then there is a short repose. The sleep is interrupted, slight fever ensues, and in the progress of time that disease either destroys the patient, when it has become inveterate, and even although it may be terminated exerts a baleful influence for a long time." Aretæus (50 A.D.) recognized, without doubt, by actual observation, that the ulcer was the peculiar and dangerous lesion of the intestine in dysentery. Matters resembling flesh, he says, come away in the discharges which accompany ulceration of the lower bowel. The flesh-like masses are shreds of the lining membrane of the intestine; healing takes place by granulation and cicatrization of the outer coat, which remains intact. That he also observed the lesions of typhoid fever, and appreciated their relation to continued and dangerous fever, is proved by the statement that, if the ulcers in the small intestine become excavated and phagedenic, acute fevers set in, which in some cases are latent and smoulder in the intestines; in other cases ardent fevers occur, accompanied by prostration of strength, thirst, anxiety, dry tongue, and small, feeble pulse.

A century later, Galen (164 A.D.) said that the physicians of his time limited the term dysentery to cases of intestinal ulceration. The shreds passed from the bowels are scrapings from the internal membranous surface of the intestine. "At first there is an excretion of very biting (*i.e.*, corrosive) bile; then shreds of the intestines follow, afterward a little blood is discharged along with the shreds, and now the affection is dysentery."

Cælius Aurelianus (400 A.D.) called dysentery rheumatism of the intestines, an error adopted by Stoll nearly four hundred years later.

Alexander of Tralles (575 A.D.) distinguished dysentery, "in which various humors are discharged by stool, from the graver variety due to ulceration of the bowels, in which shreds of the intestine are mixed with the discharges."

Other writers of antiquity, as Paulus Ægineta (660 A.D.), who made tenesmus and dysentery separate affections, Fernelius and Fabricius Hildanus, gave more or less accurate definitions of the disease and of its characteristic phenomena. Fernelius drew attention to the difference in the discharges that are found in the two varieties of dysentery, the catarrhal and the diphtheritic; in the latter form, he says, the ulcer penetrates and eats more deeply into the flesh, and the proper substance of the intestine drops out putrid or corrupted.

From this period until the revival of the study of human anatomy, in the early part of the fourteenth century, no opportunity was offered for adding any further knowledge to the rich legacy of these ancient observers. Indeed, it was not until the year 1506 that the first records of post-mortem examinations of dysenteric subjects were published in the posthumous work of Antonio Benivieni. In the writings of Hallerius (1565), Schenckius (1584), Sennertus (1626), Sydenham (1672), Bonetus (1679), and Morgagni (1762), there gradually accumulated a fund of pathological data which formed the basis for subsequent gains of positive value. Sennertus was well acquainted with the morbid anatomy, symptomatology, and treatment of the disease. He says: "Dysentery consists in frequent bloody dejections from the bowels, with pain in the abdomen and ulceration of the intestines; or it is an ulceration of the intestines with frequent bloody and purulent dejections, with pain in the abdomen and griping, arising from an acrid matter, peculiarly adverse to the intestines and eroding them." He also observed and described the difference between the sporadic and epidemic forms, and gave the indications for healing the ulcerated surface, expelling from the bowels irritating substances, and checking profuse discharges.

Following these came a host of writers, who added much to the clinical knowledge and therapeutics of dysentery by a large experience in epidemics in Europe, India, and Africa, and in armies and fleets. Among those of whom special mention should be made are: Degner (1743), Pringle (1752), Vogel and Mayer (1765), Zimmermann (1765), Stoll (1780), Rollo (1786), Hunter (1796), Desgenettes (1802), Fournier and Viday (1814), O'Brien (1822), Annesley (1828), Cruveilhier and Virchow (1842), Cambay (1847), Catteloup (1851), Dutroulau (1861), Heubner (1871), Woodward (1879), and Favrer (1881), Kartulis (in Egypt, 1885), Councilman and Lafleur (1892); Ogata (1892) and Shiga (1897) in Japan; Flexner (1890) and Strong and Musgrave (1900), in the Philippine Islands.

It is a matter for surprise to find that the ulceration in the intestine, which was considered so essential a feature of the disease by ancient observers, should have been denied by those who in the frequent study of morbid tissues had every opportunity for arriving at the truth. Pringle, in his autopsies of soldiers who had died of dysentery in Holland in 1744, observed that the mucous membrane of the intestine was black and putrid, or thickened and ulcerated, especially in the lower part of the colon and rectum; and yet Pringle, later, in consonance with the opinions of Hewson and Hunter, doubted if the intestine was ulcerated. Fournier and Viday, Chomel, Andral, and others, denied that there was ever any ulceration of the mucous membrane in acute dysentery. But Thomas, writing in 1833, of the epidemic at Tours said: "I recognized, after having made a considerable number of autopsies with the greatest care, that the ancients were right in their opinions and that the moderns are completely in error. The mucous membrane is promptly invaded by ulcerations, so numerous, so well-defined, and so constant that I claim as an undoubted fact that the ulceration of the mucous membrane is as essential a feature in dysentery as phlyctenulæ in erysipelas, le bourbillon in a furuncle, or pus in an inflammation of the cellular tissue."

PREDISPOSING CAUSES. — *Geography.* — Dysentery is ubiquitous, but it is most common, most intense, and fatal in the tropics. It prevails extensively on the southern coast-line of Asia, especially in India and in the Indian archipelago, on the east and west coasts of Africa, in Guinea, in Senegambia, at the mouth of the Niger and on the adjacent islands, in Egypt, and in Algeria. In the western hemisphere it is also a formidable disease, appearing in the southern and southwestern parts of the United States, but having a graver character in Mexico, in Central America, on the west coast of South America, in the Philippines, and in the West India islands. In all these localities it is endemic, and frequently destructively epidemic, increasing its ravages in its approach to the equator, diminishing in intensity in temperate regions, and becoming infrequent above 48° north latitude. It is met with, however, in Greenland, Lapland, Kamtschatka, and Iceland, while epidemics have occurred at Esthonia, Dorpat, St. Petersburg, Jaroslav, Novgorod, in the north of Russia, and, less frequently, in the Crimea and southern Russia. It was epidemic in Norway from 1859 to 1862, and from 1853 to 1860 it produced about 2,500 deaths annually in Sweden. In 1857 there were 37,000 cases and 10,000 deaths in the same country.

The statistics of the French army illustrate the differences in the rate of mortality in temperate and tropical regions. In France the death rate among the troops from dysentery is one-twentieth of the total mortality; in Algeria it is one-fifth; in Senegal one-third. In the English army at home the disease is rare, while in India and China more soldiers die from dysentery alone than from all other diseases to which they are liable in Europe. In Ceylon twenty-three die annually from dysentery out of every thousand of effective force.

In the United States army, in the Northern Department, three die from dysentery out of an effective of one thousand men; in the middle region the proportion is one death to every one thousand, and in Florida, it is five deaths to one thousand.

According to the report of the Surgeon-General of the United States Army, for 1900, the ratio of prevalence of diarrhœal diseases among the troops was, to 1,000 effective strength, 335.05 in Cuba, 767.61 in Porto Rico, 399.60 in the Pacific Islands, and 374.19 in the United States. The differences in mortality, however, were very great. The death rate was 0.12 in Cuba, 0.35 in Porto Rico, 2.02 in the Pacific Islands, and 0.34 in the United States. During a period of ten months there were treated in the First Reserve Hospital, Manila, 1,328 cases of dysentery or 14.64 per cent. of the total cases.

In regard to the distribution among the civil population, the more temperate and colder regions do not, however, seem to have a greater immunity than the southern and southwestern parts of the country. Sporadic dysentery prevails in all parts of this country and has proved most fatal in the New England States. In the Atlantic States the greatest mortality from dysentery in 1850 was in Connecticut and Massachusetts, in 1860 in Massachusetts and Virginia, in 1870 in Vermont and Massachusetts. In 1850 the deaths from dysentery in Ohio and Indiana exceeded by far those in the Gulf States. The history of epidemic dysentery shows a wider spread in the New England States, between the years 1749 and 1798, than elsewhere, and since these years epidemics have not shown a preference for any one region.

Topography and Conditions of the Soil.—Efforts have been made to associate dysentery with special topographical or geological features, but no such association exists. Dysentery prevails in countries and in localities which differ widely in these respects. It is strange that epidemics of dysentery have been more general and more fatal in the country than in the city. This was the case in the epidemic of 1774 in France, and in the epidemics in Germany between the years 1795 and 1829. When epidemics prevailed in the country, the disease was often sporadic in the cities.

When houses are built upon a low, damp soil, and when the soil in the immediate neighborhood of buildings, as hospitals, barracks, or prisons, is saturated with moisture, a favorable condition exists for the propagation of dysentery. Kelsch and Kiener have shown a connection between dysentery and low-lying, swampy, and ill-drained localities.

Emanations from a wet soil are probably prejudicial to health, and exert a depressing influence which is favorable to the inroads of disease. Dr. Baly, in 1842, with a view of ascertaining the cause of frequent epidemics of dysentery in Millbank Penitentiary, visited many prisons, barracks, workhouses, and lunatic asylums in England. The bowel complaints, he found, bore a close relationship to the site of the institution. They were infrequent where the building was erected on an elevation, with a dry soil and a gravelly subsoil; but very frequent if the situation was low, the soil wet from imperfect drainage, and the subsoil of peat. But dysentery does prevail in elevated and dry plateaus in India, Mexico, and Peru.

A soil saturated with dysenteric excreta is a fruitful source of the disease. This is shown in the fact, mentioned by Czernicki, of the breaking out of dysentery in two French squadrons which in 1875 occupied ground where a cavalry regiment affected with dysentery had previously camped. A similar occurrence was noted at Châlons in 1890.

Overcrowding and Imperfect Ventilation.—The overcrowding of human beings in badly ventilated buildings or ships is often followed by outbreaks of dysentery. It was not rare for a slave-ship, in making the transit from Africa to America, to lose three-fourths of her living cargo from this cause. In prisons, reformatories, etc., before attention was paid to such matters, epidemics of dysentery were frequent and destructive. This was due in part to the deterioration of health from imperfect ventilation, and in part to the accumulation and improper disposal of fæcal matter.

Season and Temperature.—In all climates dysentery is most prevalent in the hot season. In the United States August is the month of its greatest mortality, and in the summer and early autumn the largest number of cases occur. This is true of sporadic as well as of epidemic dysentery. Hirsch has collated the histories of 546 epidemics, of which 404 were in the summer and autumn, 113 in the autumn and winter, 16 in the spring and summer, and 13 in the winter. Figures given by Kelsch and Kiener show the same preponderance in summer and autumn. The minimum mortality in this country is in January and February.

Elevation of temperature conduces to the origin and spread of dysentery. Unusual heat preceded the epidemic of 1813 in Holland, of 1834 to 1836 in France, Switzerland, Belgium, and Germany, of 1853 in Sweden, and of 1859 in France. In the Franco-Prussian War of 1870, in the wars of Italy and the Crimea, and in the civil war of 1861–65 in the United States, the relationship between extreme heat and dysentery has been shown; but the fact that campaigns are chiefly conducted during the summer adds the effects of other causes to heat influence. That there is no necessary relationship between dysentery and extreme heat is shown by the rarity of the disease in the cities of the Atlantic seaboard in seasons of long-continued high temperature. Epidemics have appeared in cold weather in Russia, Sweden, and Canada. In Ireland an epidemic lasted from autumn until spring, and in 1732 there was an epidemic in Siberia in January. Of 13,900 cases in Bengal there were 2,400 in the cool season, 4,000 during the warm and dry season, and 7,000 in the period of warmth and moisture. In warm climates endemic dysentery lasts throughout the whole year. Dutrouleau says of 100 deaths from dysentery in Martinique 18.76 took place from January to March, 20.55 from April to June, 27.73 from July to September, and 32.96 from October to December.

Atmospheric Moisture.—The saturation of the air with moisture is recognized as offering another favorable condition for the spread of dysentery. Heat and moisture combined enfeeble the individual, and favor putrefactive decomposition in animal and vegetable matters, and hence assist materially in the propagation of disease. Moisture alone is not an essential factor, however, as out of 119 epidemics 62 were preceded by moist, and 57 by dry weather.

When cold and atmospheric moisture are combined the effect upon the individual is the same, and dysentery may result. Thus, Pringle states that at the battle of Dettingen, the French army was exposed to an abundant rain, and the soldiers spent the night in their wet clothing. A large number were attacked with dysentery, while a corps stationed at some distance, and not thus exposed, escaped illness.

Vicissitudes of Temperature.—The season of dysentery has been said to be when cooler nights succeed hot days, and when sudden changes of weather occur. In tropical countries oscillations of temperature, after periods of prolonged heat, often precede epidemics, and the same thing has been noted in temperate climates. Pruner in Egypt, Lame in Guiana, McMullin in the Barbadoes, Ruthay in China, and Lavacher among the negroes at Santa Lucia, have noted the appearance or aggravation of dysentery after sudden and marked temperature variations. In armies on the battlefield or in exposed camps, dysentery follows unusually cold nights or sudden changes in temperature, the officers always suffering less, however, as they are better clothed and better protected against such influences. It is not now thought, however, that variations of temperature have much influence in causing outbreaks of dysentery, although formerly this was a prevailing belief.

Impure Water Supply.—From the earliest times bad drinking-water has been believed to be a potent cause in originating dysentery. But no part of the study of the etiology of the disease gives a better idea of the contradictory nature of the evidence than that upon which a belief or disbelief in the evil influence of impure drinking-water is based. Read in 1770 noted that, in an epidemic at Metz, a regiment occupying a certain caserne had ninety-one cases of dysentery, while other regiments suffered much less. The soldiers of this regiment used water contaminated by sewage from neighboring privies, and the closure of the infected wells was followed by a diminution in the number of cases. This is an early observation which is the counterpart of an innumerable number of the same sort. Cases and epidemics have been traced to the use of water contaminated with sewage, with animal excrement, and with matters from animal and vegetable decomposition. The cutting off of the supply from the contaminated source has frequently not prevented outbreaks of dysentery, nor stopped the spread of it. The use of rain water in ships at infected foreign ports is not a preventive, nor do the Chinese escape who, according to Dudgeon, invariably use boiled water. In the Millbank penitentiary three hundred and fifty prisoners were given pure water from an artesian well, while seven hundred drank Thames water, but intestinal diseases were as common in the one class as in the other. On the other hand, an epidemic of dysentery began on the Pacific Mail steamer *Alaska*, and several of the crew were attacked eight or ten days after the tanks were filled at Hong-Kong. The water in the tanks was found to be filled with bacteria; the crew was put on condensed water and the further spread of the disease stopped. Davis mentions that at Tortola, in the West Indies, the inhabitants use rain water only, and while they escape, the ship's crews are invariably attacked with dysentery. So well known is this that the residents, when invited to dinner on board a man-of-war, frequently carry their own supply of drinking-water with them.

Other observers mention facts which are in direct opposition to these. In 1848, two French ships-of-war, the *Brandon* and the *Embuscade*, visited St. Pierre. A violent epidemic of dysentery attacked the crews, who used distilled water, or water brought from France. The merchant ships in port, which took no such precautions, escaped the disease.

The workmen engaged in the Suez Canal had a greater immunity from dysentery after 1863, when the purer water of the Nile was obtained. Lalluyaux d'Ormay demonstrated at The-dau-Not, in Cochin China, that dysentery could be produced or arrested at will by using or not using certain waters. In China the water of certain rivers is notoriously dangerous to health, and produces dysentery. Thévenat, in his work on "Diseases of Europeans in Warm Climates," says nothing is so prone to lead to disorganization of the large intestine as infected water. The cause of contradictory evidence is now easily understood. Impure water *per se* cannot produce dysentery; the water must contain the infecting micro-organism as one of its impurities.

Improper Food Supply and Indigestion.—The occurrence of dysentery has long been associated with errors in diet, and with indigestion and food decomposition in the intestinal canal. Acute indigestion, after taking food in excess, or when it is unfit for use, may lead to diarrhœa or dysentery. The acrid matters, which were dwelt upon by the Greeks as causes of dysentery, arise from the putrefactive changes in the intestinal contents, and are, without doubt, agents in exciting inflammation and in predisposing to dysenteric infection.

Individual Predisposition.—Age.—No age is exempt from dysentery. It is asserted by Zimmermann that infants whose mothers have dysentery are born with it. Young children, in the hot season in temperate climates, are prone to it, but not to the same extent as to diarrhœa. Recruits from nineteen to twenty-one years of age, newly arrived in India and Algeria, are more liable to contract the disease than older soldiers. In the French navy the same predisposition has been noticed among the young apprentices. In the old, dysentery is a common and fatal affection.

Sex.—Dysentery is more prevalent among males than among females.

Race.—All races and nations are subject to sporadic if not to epidemic dysentery. The natives as well as foreigners are attacked by it, and its fatality is usually greater among the native population. In this country the opportunity is given to contrast the disease as it affects the white and black races. Campbell, of Georgia, has described an epidemic which involved the whites only, but this is an isolated observation. In an epidemic in Byhalia, Miss., in 1883, both the masters and servants succumbed to dysenteric symptoms; in a radius of ten miles, out of 100 deaths, 85 were from this cause.

A race out of its own habitat is a greater prey to dysentery, owing to the adoption of a mode of life and diet which are unsuited to the necessities of the climate.

Condition and Habits of Life.—Dysentery is more fatal among the poor than among the rich, and it is especially fatal among the poorly clothed and badly fed. Overfatigue, loss of sleep, and anxiety favor the onset of the disease. Indulgence to excess in alcoholic liquors is thought to be a cause in hot climates, but as errors of diet, exposure, fatigue, and a general disregard of the rules of health accompany alcoholic indulgence it is probable that alcohol alone is not an active cause.

Influence of Other Diseases.—The relation of scurvy to dysentery has been much dwelt upon. During the civil war in this country the concurrence of diarrhœa, dysentery, and scurvy was frequently noted. All followed prolonged deprivation of vegetable food, the hardships of camp life or exposure in the field, but that there is no causal relation between scurvy and dysentery is abundantly proved by experience everywhere. Of fifty cases of scurvy admitted into the European General Hospital, Bombay, in 1863, only one had dysentery.

In epidemics of cholera, a transition of the choleraic into dysenteric symptoms has sometimes occurred, and in fatal cases of cholera lesions similar to those characteristic of dysentery have been found.

A very general belief has prevailed as to the close association of malaria and dysentery. In the Southern and Southwestern States the coincidence of "bilious" fever and dysentery, the two diseases frequently appearing in the same individual, and arising apparently under the same conditions, led to the opinion that both diseases are due to one and the same poison, developed in the decomposition of vegetable matters. But the geographical history of dysentery shows that conditions leading to malarial disease are by no means necessary to originate dysentery. Dysentery and malaria prevail independently of each other when there are the same conditions of season, soil, and climate. An epidemic of dysentery occurred in San Joaquin Valley, Cal., in May, June, and July. Malarial fever prevailed in August, September, and October of the same year. In Trenton and Gibson Counties, Tenn., in the autumn of 1881, a maximum of dysentery was reached while there was but little malarial disease. In 1874 and 1875, when intermittent fevers were so rife that there were not well persons enough to care for the sick, there was scarcely one case of dysentery.

The discovery of the malarial parasite and the belief in the parasitic origin of dysentery have done away entirely with this once common opinion. Such coincidences of malarial fever and dysentery or of dysentery and typhoid or other specific fevers are examples of double infection.

Dysentery complicates various acute and chronic disorders, and these, with former attacks of dysentery, and all previous states of ill-health, may be regarded as predisposing to its development.

Constipation has been thought to bring about dysentery, the hardened fæcal masses acting as foreign bodies in the colon and rectum. Cullen held that the griping, frequent stools, and tenesmus were caused by their presence.

Forms of Dysentery.—The term dysentery is now known to include several diseases unlike in their etiology and pathological anatomy, occurring under different conditions of climate and locality, although resembling each other to some extent in their symptoms. For convenience they are spoken of as forms of dysentery, although their differences are great enough to deserve separate classification.

The classification most usually adopted of sporadic, tropical or endemic, and epidemic or diphtheritic dysentery was based upon clinical and pathological differences, but our present knowledge shows that the differences between these forms are not great enough to justify this distinction. The study of the etiology of the disease has now advanced so far that we are justified in stating that there are several, perhaps many forms of so-called dysentery, each due to infection by some specific micro-organism. It is not certain, however, that any one variety is limited geographically, nor what the relation may be between the dysenteries of different climates and countries. So far, the only forms that are definitely placed are the dysentery due to the Amœba coli and that due to the Bacillus dysenteriæ. It seems probable that in time etiological research will lead to the entire abandonment of the term dysentery.

Sporadic dysentery or the dysentery of temperate climates is described separately on account of its clinical features.

I. Acute Catarrhal or Sporadic Dysentery.

Etiology.—Nothing is definitely known as to the bacteriology of catarrhal dysentery. Without doubt it has a specific cause, probably a bacillus which has so far eluded discovery. Etiologically it may be the same as the bacillary dysentery of Manila; the disease cannot arise from chemical or mechanical causes.

Pathological Anatomy.—The mucous membrane of the rectum and lower bowel is inflamed. In the milder forms there is no change beyond a more or less intense hyperæmia of the mucous membrane over areas of varying extent. Punctiform hemorrhages are seen in the mucosa or submucosa. The mucous coat is swollen and covered with much mucus, pus, and red blood cells. The surface epithelium is absent, and the exfoliation of epithelium may involve the glands. There is sometimes destruction of the tissue of the mucous membrane; shallow ulcers are seen, formed by extension of the superficial softening. Sometimes the ulcers extend to the muscular coat. In the submucosa, which is much thickened, there are masses of granulation and pus cells, and the connective-tissue cells are enormously swollen. The solitary follicles are swollen and from distention they burst, thus forming an ulcer.

Symptoms.—In the milder forms of the dysentery of temperate climates the attack may begin with diarrhœa and with premonitory distress in the abdomen and tympanites. Colicky pains follow; the evacuations very soon, sometimes at once, are characteristic of dysentery; they are small, contain or consist wholly of mucus, and are stained with blood. The griping pains, as the attack advances, recur at short intervals in the region of the umbilicus, in the line of the ascending and descending colon, extending to the left iliac fossa. The urgent desire to empty the bowel follows each paroxysm of pain, and with great straining (tenesmus) a small muco-sanguinolent mass is expelled. The patient continues his unrelieved expulsive efforts and complains of burning in the anus. In cases of this kind there may be very little fever or none at all, but the degree of weakness is out of proportion to the mildness of the attack. The patient improves gradually after a few days and is well at the end of a week or ten days.

In severer forms, lasting ten, fourteen, or twenty-one days, these same symptoms are intensified, especially the constitutional symptoms; the pulse is more frequent and feeble, and the temperature ranges from 101° F. to 103° F. The strength undergoes a more rapid reduction, the effect of the violent and frequent abdominal pains and the frequent mucous and bloody stools, which are attended with great straining, and with the sensation as if a foreign body were in the rectum. In the beginning the discharges are composed of a viscid mucus floating in a serous liquid. On the second or third day blood is mixed with the mucus, and there is less fluid. After the fifth or sixth day blood is passed with muco-purulent or purulent fluid, the source of which is the ulcerating mucous membrane. Gradually the stools become more abundant, and consist of a dirty white or grayish fluid, of a slightly fœtid odor. Their number varies from twenty to forty in the twenty-four hours, being more frequent at night, but there is no limit, as many as two hundred having been noted.

The progress of the attack is attended with fever, with thirst, sometimes with delirium at night, always with restlessness and insomnia; the abdominal pains are so severe as to excite cries, and the prolonged expulsive efforts cause great exhaustion and profuse sweating. Vesical tenesmus accompanies rectal tenesmus, and prolapse of the bowel is not infrequent, especially in children. A sensation of oppression in the epigastrium and vomiting are due to reflex influences.

The loss of strength is rapid, the pulse grows feeble, and the patient lies on one side with the knees drawn up. If recovery is to be the result there will be a diminution in the number of the stools and a return of fæcal matter. Death is preceded by offensive fluid movements. Such attacks may pass into the chronic form.

II. DYSENTERY DUE TO (1) THE AMŒBA DYSENTERIÆ AND TO (2) THE BACILLUS DYSENTERIÆ.

Etiology.—Amœbæ were first seen by Lambl in the intestinal contents in 1859. In 1875 Lösch, in examining microscopically the stools of a patient, twenty-four years of age, who was suffering with an ulcerative affection of the large intestine, discovered an amœba which appeared in great numbers; this he called "amibe du colon" or amœba coli. Next he injected these stools into the intestines of two dogs, one of which had vomiting and diarrhœa. The animals were then killed, the intestines were found to be inflamed, were covered with bloody mucus, and showed many ulcerations. The amœbæ were found in the mucous membrane and in the ulcers. The parasite appeared as a protoplasmic mass and measured on an average 20 to 50 μ; in motion and with their greatest elongation they reached over 60 μ. Their protoplasm was very granular and enclosed six or eight round vacuoles.

Koch, in 1883, found the amœba in the intestines of those dying from Egyptian dysentery. Kartulis in 1885 attempted to prove that the amœbæ played the principal rôle in the pathogenesis of dysentery. He also found them in other ulcerative affections of the intestine, viz., in typhoid fever and in tuberculosis. In certain complications of dysentery, and especially in abscess of the liver, Kartulis found the amœbæ in the pus, associated nearly always with the ordinary microbes of suppuration. Osler, first in America, reported a case of abscess of the liver which developed in the course of dysentery and in which he found the amœbæ in large numbers. Much that we know of this form of dysentery is due to the work done in Johns Hopkins Hospital by Osler, Councilman, and Lafleur, and we are indebted chiefly to the paper of Councilman (Transactions of the American Association of Physicians, 1892) for our knowledge of the pathological anatomy of amœbic dysentery. Dock afterward demonstrated the amœbæ in a case of dysentery contracted in Texas. Vassi has since found them in a case of abscess of the liver; he found only a small number in the pus, but they were present in great numbers on the side of the abscess, also in some of the small branches of the portal vein.

These observations seemed at one time to have definitely fixed the amœba as the one infecting micro-organism in tropical dysentery, and the name "amœbic dysentery" took firm root in medical literature.

The fact that amœbæ are found in other diseases, as in cholera and typhoid fever, and in the intestines of healthy persons, threw doubt upon the theory that this was the infecting micro-organism of dysentery. The inference is, that there are intestinal amœbæ which are harmless or which at any rate do not produce dysentery. These have been injected without effect into the rectum of cats. On the other hand, Strong and Musgrave assert that they have had no difficulty in producing dysentery with ulceration of the large bowel by injecting stools or contents of liver abscesses containing mobile amœbæ dysenteriæ. Councilman and Lafleur believed that there were a number of species of amœbæ which may inhabit the colon.

From recent experience in Manila, as well as from previous studies, it may be concluded that there is an amœbic dysentery. As amœbæ, however, were not found in all cases of dysentery, either in the stools or in the intestinal tissues after death, doubt was raised as to whether the amœba was the only cause of dysentery.

Bacilli were found in the stools of dysentery, and in the glands or walls of the large intestines, by Klebs (1887), Ziegler (1892), Chante-Messe and Widal (1888), Grogorieff (1892), Laveran (1893), and Arnaud (1894).

Celli and Fiocca (1895), studied 62 cases of dysentery and concluded that the amœba coli is not the cause of this disease. They found a colon bacillus, called by them B. coli dysenteriæ, having special virulence, which they considered responsible for the lesions in all cases. With this bacillus they caused dysentery in cats, and a toxin separated from it produced the same results. Celli in the next year reported that he invariably succeeded in isolating B. coli dysenteriæ from dysenteric cases.

In epidemic dysentery in Japan Ogata (1892) found no amœbæ but he isolated fine bacilli which, when introduced by the mouth or rectum, caused intestinal ulceration in cats. More recent observations were made by Shiga in Japan during an epidemic in 1897 when 22,300 deaths, 24 per cent., occurred out of 89,400 cases. A bacillus was isolated that fulfilled all the requirements to give it the place of causative agent. It was found in the intestinal contents and walls and in the mesenteric glands in 36 cases.

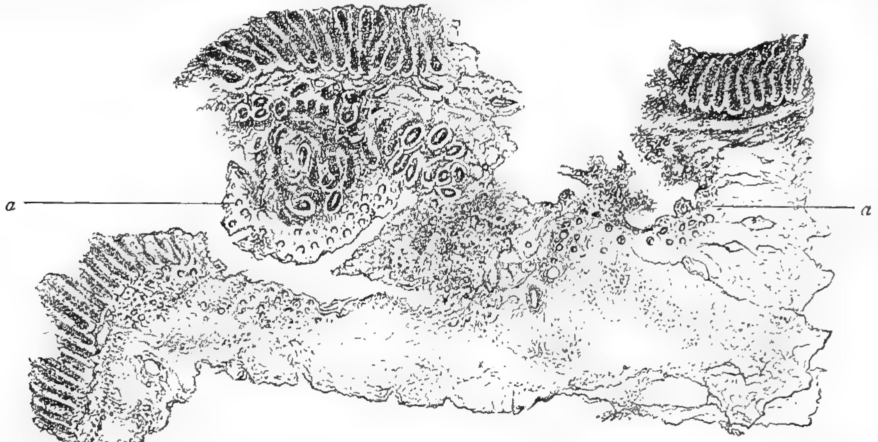

FIG. 1673.—Acute Amœbic Dysentery. Spreading Ulcer. *a, a,* Amœbæ in the Submucosa. Enlarged 80 times. (After Kartulis.)

Flexner in his bacteriological studies of Philippine dysentery in 1899 obtained cultures of two types of bacilli from the intestinal walls and contents. Type I. was found in acute cases; it was pathogenic for laboratory animals. Type II. was present in all dysenteric cases, but less prominent than Type I. in acute cases. It was not found in healthy persons or in those suffering from other diseases. These observations confirm Shiga's results.

The report of the Surgeon-General of the United States Army, for the year ending June 30th, 1900, contains a very full and interesting report by Strong and Musgrave on the etiology of the dysenteries of Manila. In a period of ten months there were, in the First Reserve Hospital, Manila, 1,328 cases of dysentery, being 14.64 per cent. of the total of 9,063 cases of illness admitted. One hundred and eleven autopsies were made on dysenteric cases; 21 of these were classed as "acute specific dysentery," 11 as "subacute specific dysentery," and 79 as "amœbic dysentery." A bacillus was isolated in 17 out of the 21 cases of acute dysentery and in 2 out of the 11 cases of subacute dysentery; this bacillus was similar to that found by Shiga at Tokyo in 1897. Strong and Musgrave regard this Bacillus dysenteriæ as the cause of these acute and subacute forms, and thus their conclusions agree with those of Shiga and Flexner.

This opinion is supported by the voluntary ingestion, by an Indian criminal condemned to death, but in perfect health, of a forty-eight-hour bouillon culture of Bacillus dysenteriæ in warm milk. In twenty-four hours characteristic dysenteric stools appeared, with fever; the stools contained mucus, cells, and bacteria, but no amœbæ. This attack ended in recovery.

Flexner, Strong, and Musgrave describe minutely the bacilli found by them; they were pathogenic for mice, guinea-pigs, rats, and rabbits; injected into the rectum of cats and dogs they did not produce dysenteric lesions or symptoms. In 26 cases of dysentery which presented different lesions and in which amœbæ were present the Bacillus dysenteriæ was not found.

The blood serum of acute and subacute cases of the acute specific dysentery has an agglutinative reaction with the B. dysenteriæ by the third day; it is marked by the fifth or sixth day.

(1) AMŒBIC DYSENTERY.—This form of dysentery is endemic in India, Egypt, the Philippine Islands and elsewhere in the Tropics. It has been met with as a sporadic form in the United States. Osler says that the cases of acute and chronic dysentery admitted to his wards in Johns Hopkins Hospital have been almost exclusively of this form.

Pathological Anatomy.—The sigmoid flexure is the chosen seat of disease; it may involve the ascending or descending colon, or the whole of the large bowel at one time. The intestine is thickened; the mucosa coated with a muco-sanguineous secretion is intensely hyperæmic, swollen, and in places ecchymotic. The solitary follicles appear as grayish-white points, surrounded with an areola of injected vessels. Nodular projections of the mucosa are seen; they result from œdema and cellular infiltration of the submucosa. This condition is followed by an ulcerative process, beginning in the submucosa and undermining the mucous layer above. These overhanging layers next fall off, leaving large exposed ulcers, which may deepen until the muscular coat is exposed and forms the base of the ulcer. The ulcerative process is thought by Kruse and Pasquale to begin in the solitary follicles, but according to Councilman and Lafleur the origin is in the submucosa.

Amœbæ and other micro-organisms are found clinging to the mucous surface and penetrating into the intertubular spaces. Kartulis believes that the amœbæ destroy the epithelium, penetrate the lymph channels and finally reach the submucosa, exciting inflammation and necrosis. He does not agree with Kruse and Pasquale that the bacteria co-operate in causing the lesion of dysentery, but is more in accord with Councilman and Lafleur as to the exclusive agency of amœbæ.

The necrosis once begun leads to various forms of destructive metamorphosis—small cavities in the submucosa, deep round and irregular ulcers with undermined edges, serpiginous ulcers, and small follicular ulcers; the ulcers extend into the submucosa; the base is rarely formed of the muscular or serous layer. Some ulcers are covered with a slough of necrotic tissue.

The ulcers in the early stages are scattered at varying distances throughout the colon. Later, by the spreading of neighboring ulcers and by the undermining and destruction of the intervening tissue, the mucosa is converted into a ragged surface with hanging shreds and fringes of undestroyed mucous membrane. This advanced process may be limited to certain small areas or may extend throughout a considerable portion of the colon. (See also article on *Amœbæ Pathogenic for Man,* in Vol. I.)

Abscess of the liver was found in six out of eight of the autopsies of amœbic dysentery (Councilman); in four cases there was more than one abscess, and in two cases they were very numerous and small; in every case the right lobe was the seat of this change, and in two cases there were abscesses in the left lobe. In the smaller abscesses there was a small amount of glairy, semi-transparent fluid; in the large ones the contents were more fluid, of a grayish color, sometimes brownish-red from admixture with blood. A distinct limiting wall, sometimes dense and hard, is found in the larger abscesses, but it has not been seen in the smaller ones.

The fluid of the smaller abscesses is composed of fatty, granular material, fragments of liver cells, and pus and lymphoid cells; that of the larger abscesses contains fat, red blood corpuscles, fragments of liver cells, and very few pus cells. Amœbæ were contained in both, but were more numerous in small and recent abscesses.

The following table gives a summary of the relations of abscess of the liver to dysentery, as deduced from observations in India.

TABLE A.

Authority.	Locality.	Number of cases of dysentery.	Number of cases of abscess of liver with dysentery.	Other alterations in the liver.	Liver healthy.	Per cent. of abscess of liver in cases of dysentery.
Murchison	India	......	102			
Horton	India	55	6	....	....	10.9 +
Dr. McPherson	Calcutta Hospital	160	21	....	....	13.1 +
	Calcutta Med. College Hospital	245	......	124		
Mr. McGregor	India	21	......	16		
Dr. Shanks	Madras	96	36	....	....	37.5 −
Dr. Janis	Madras	43	8	....	....	18.3
Dr. Monat	Madras	61	13	30	18	21.32
Dr. Hamilton	Madras	17	0			
Dr. William Dix	Madras	26	9	....	....	34.6 +
Dr. Thompson	Madras	11	2	....	....	18.18 +
Dr. McGregor	Madras	5	1	....	....	20. −
		259	69			26.6
Dr. McPherson	Bengal	293	46	....	....	16.04 +
Dr. Morehead	Bombay	32	13	....	....	40.6 +
Dr. Stovell	Bombay	49	21	....	....	42.8 +
		81	34			41.9 +
	Madras, Bengal, Bombay	633	149	....	....	23.53
Waring	India	......	96			
Fayrer quotes Moore.	....	1,663	347	....	....	20.87 +
Parkes	India	98	43	50	6	43.9
Reynolds	Netley Path. Museum	25	3	....	....	12.0
Schneider	....	1,400	57	385	10	4.07
Béranger-Féraud	Senegal	411	143	170	98	34.79
Annesley	....	29	21	....	....	72.41
Haspel	....	25	13	....	....	52.0
Gluck	....	151	16	....	....	10.59
Grand total	....	4,916	1,028	775	132	20.91

Strong and Musgrave found liver abscesses in 14 out of 97 cases. Other changes in the liver consist in extensive necrosis in the centre of the lobules, the capillaries and necrotic cells containing numerous leucocytes; but amœbæ are not associated with the necrotic process; they are found only in association with the abscesses.

Abscesses are found also in the lungs; they occurred in three out of eight cases, and were seated in the lower lobe of the right lung in every case. In two cases the lung abscess communicated with a liver abscess through a perforated diaphragm. The abscess cavity in the lung was surrounded by consolidated tissue of great extent, embracing the entire lobe. The contents of the abscesses were granular detritus, round lymphoid cells, red blood corpuscles, pus cells, and amœbæ. A definite wall sometimes included the abscess. The amœbæ are more numerous in alveoli immediately adjoining the abscess, and in those places where the abscess is most rapidly advancing, and where there is no limiting wall or connective tissue; but all the neighboring tissues contain them.

Symptoms.—The symptoms of amœbic dysentery are not uniform or characteristic. The cases are either acute or chronic.

Acute Amœbic Dysentery.—There is a catarrhal and an ulcerative stage. In the former a moderate fever and even a slight chill may be present at the onset. The temperature soon returns to normal, or, if it continues high, this points to a severe intestinal lesion or to the involvement of other organs, *i.e.*, liver or lungs. The stools are at first diarrhœal in character, not very numerous, and soon become typically dysenteric. They may, however, be dysenteric from the beginning, with little or no odor, and alkaline in reaction. Amœbæ when present are found in the muco-bloody portions. Pain is usually present in the region of the navel; the entire colon, and frequently the cæcum, are sensitive to pressure. Tenesmus appears coincidently with dysenteric stools, and points to beginning ulceration or to involvement of the lower colon and rectum.

The ulcerative stage may begin with cholera-like symptoms, chill, rapid rise in temperature, diarrhœa and vomiting, burning thirst, and pain in the legs. The tongue is dry and chalky. The stools are usually very numerous, from twenty to thirty in twenty-four hours; they contain much blood and soon become dark brown and fœtid. The colic and tenesmus are severe, and large pieces of necrotic mucous membrane are often passed in the stools. Micturition may also be very painful and the entire abdomen, especially in the region of the colon, is acutely sensitive. In the more severe cases, with gangrenous destruction of the mucous membrane, the temperature rapidly sinks to normal or subnormal, the extremities become cold, and the patient soon dies in col-

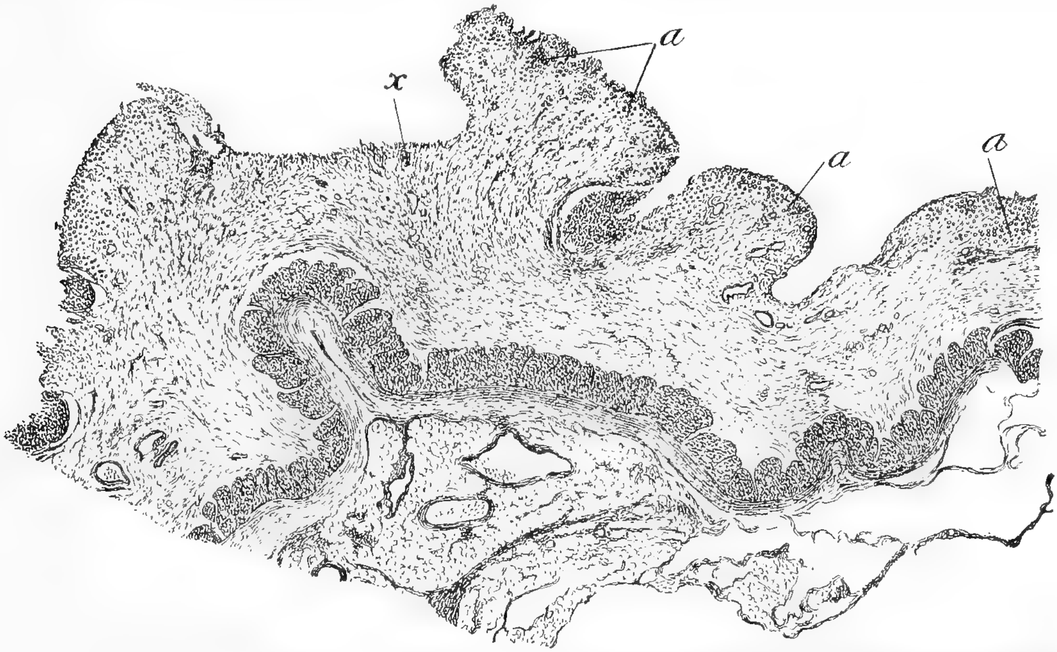

FIG. 1674.—Dysentery Due to Bacillus Dysenteriæ. Section of colon showing thickening of submucosa; *a*, *a*, *a*, superficial necrotic layer of mucosa with areas of hemorrhage; *x*, loss of superficial layer. Enlarged 80 times. (Section from a specimen in the Army Medical Museum.)

lapse. Consciousness is usually maintained to the end. Hemorrhage and perforation of the bowels may occur.

Severe attacks of amœbic dysentery may follow a very mild beginning, and with early and proper treatment even severe attacks may be cured. Spontaneous cure is very infrequent. The course of the disease is irregular, with frequent intermissions and exacerbations, and shows a strong tendency to become chronic.

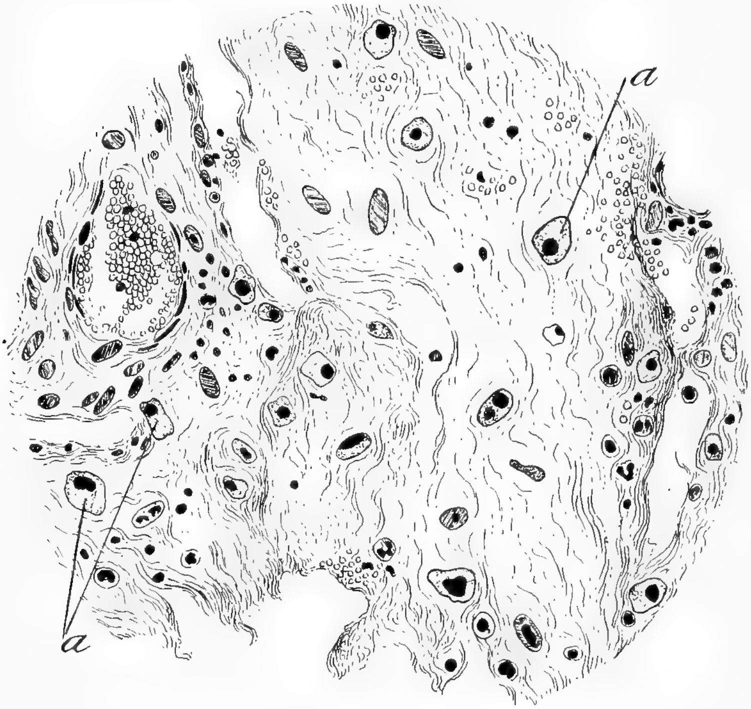

FIG. 1675.—Dysentery Due to Bacillus Dysenteriæ. (Section of area *x* in Fig. 1674.) Fibrinous infiltration and plasma cells (*a*, *a*) in the submucosa. (Enlarged 300 times.)

Chronic Amœbic Dysentery.—This may follow a subacute attack or be chronic from the beginning. The progress is irregular, exacerbations alternating with periods of improvement during which the patient goes about. If a soldier he performs his duties, entering the hospital from time to time with subacute attacks. During the interval the bowels may be constipated, and the patient looks well and is well nourished. The duration is long. Death results from liver abscess, from perforation peritonitis, from other complications, or from exhaustion.

(2) DYSENTERY DUE TO THE BACILLUS DYSENTERIÆ.—This variety, first described by Shiga in Japan and by Flexner and Barker, and by Strong and Musgrave in the Philippines, is endemic in these localities, but may become epidemic, as noted by Shiga. A small epidemic occurring in Germany was described by Kruse. Flexner has observed one case in the Pennsylvania Hospital, but further study is necessary to decide whether it prevails in this country.

Pathological Anatomy.—The disease resulting from infection with B. dysenteriæ appears in both an acute and a chronic form, each having peculiar lesions.

In the acute form the serous coat of the large intestine is hyperæmic. Near the sigmoid flexure and upper part of the rectum the vessels of the mesentery are distended. The wall of the colon is thickened; the degree and extent of this change bearing some relation to the intensity and duration of the attack. The mucosa and submucosa show a relatively greater increase in size as compared with the other coats. The surface of the mucosa, from the anus to the colon, is red or brownish-red in color, with ecchymotic patches and covered with a layer composed of necrotic tissue, blood, mucus, and epithelium. The mucosa is hypertrophied, forming nodulated areas that give to the surface an irregularly corrugated appearance. These ridges are probably more marked in cases of longer duration and less marked when death takes place within the first week. The change is somewhat greater in the lower colon than elsewhere.

There are no ulcers, but there is an irregular superficial erosion of the surface of the mucosa, that gives to it a worm-eaten appearance.

One of the most characteristic features of this form of dysentery is the extension of the inflammatory process into the ileum for a distance of from 10 to 15 cm. This condition does not exist in amœbic dysentery and is found in one-third of the cases. Peyer's patches and the solitary glands may be moderately swollen.

In the subacute form the mucosa is less red, the solitary follicles are swollen, hemorrhagic, and of a dark red color. The surface of the bowel is uneven, often mammillated, and the necrotic layer is less marked. There are superficial erosions, but no ulcers as in amœbic dysentery, and less thickening of the intestinal walls than in the acute form.

*Pathological Histology.**—The surface of the mucosa is covered with a pseudo-membrane composed of a fine network of fibrin enclosing multinuclear cells and free red blood corpuscles, or, as shown in Fig. 1674, *x*, the mucosa may also be involved in this process of coagulative necrosis and, in small areas, may separate from the submucosa. To the change in the submucosa is chiefly due the great thickening of the gut. It is very œdematous, appears in places almost homogeneous, and shows a large quantity of fibrin. There is an absence of infiltration with leucocytes. Scattered hemorrhages are abundant and large lymphoid cells and Unna's plasma cells appear in great number, especially in the neighborhood of the blood-vessels. These changes may take place beneath an intact mucous membrane. The serous coat is usually œdematous, and the blood-vessels are injected, but hemorrhages are uncommon. The bacilli and cocci are abundant in the necrotic mucous membrane and are said by Strong to be seen in all the coats.

Symptoms.—The incubation period lasts not over forty-eight hours. The onset is sudden, with frequent stools, consisting of mucus which is soon mixed with blood. The movements accompanied with tenesmus increase in frequency, except toward the end of fatal cases, when they become less frequent. The tongue is coated with a whitish fur and there is excessive thirst. Nausea and vomiting may occur.

The abdomen is not usually distended and there may be tenderness on deep pressure over the colon. The spleen is not often enlarged.

The temperature rises to 102° or 103°, or even to 104° F.; it runs an irregular course and rises or falls before death. The pulse ranges from 100 in the early stages to 150 or more as the disease advances.

Lobar pneumonia, broncho-pneumonia, acute bronchitis, and fibrino-purulent pleurisy are met with.

There is severe headache, and delirium may be present in prolonged and fatal cases. The urine is decreased in amount and may contain a small amount of albumin. The liver is not enlarged or tender and liver abscess is never found in this form. There may be a moderate leucocytosis.

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* The description here given of the pathological changes in bacillary dysentery is based upon a study of specimens brought from Manila by Dr. E. R. Hodge, and now in the Army Medical Museum, Washington. By the kind permission of Major Walter Reed, U. S. A., Curator of the Museum, the drawings, illustrating the text of this article, were made from sections of these specimens.

The progress and duration of the attack are variable. The most violent stage rarely lasts a week. Strong and Musgrave report that out of their 21 acute cases which came to necropsy, 4 patients died on the fourth and 4 on the fifth day of the disease; 10 others died before the fifteenth day, but none under three days' illness. In the cases that are early fatal the extent of the anatomical changes in the intestine indicates how virulent is the inflammatory process. It is remarkable how great a degree of thickening of tissue can be brought about in so short a time. Recovery is rare in the more severe cases.

In the cases that end in recovery improvement may set in at the end of the first week, the patient entering upon convalescence by the end of the second week; or the disease lasts in a subacute form for months, with thin and bloody mucous stools. One of Strong's patients died on the sixty-fourth day.

When convalescence begins, the patient is feeble and much emaciated and improves very slowly.

Complications.—There is no disease which has a larger number of complications than dysentery. Out of 1,537 cases of diarrhœa or dysentery observed in Egypt only 406 were uncomplicated; 1,131 were complicated with other more or less severe affections. The following list includes many of these, which may occur during the progress or as sequelæ of the disease: catarrh of the stomach and small intestines, acute bronchitis, pleurisy, pleuropneumonia, gangrene of the lung, albuminuria and anuria, ascites, anasarca, meningitis, thrombosis in the cerebral sinuses, convulsions, cerebral embolism with hemiplegia and aphasia, paraplegia, ulcer of the cornea, abscess of the liver, other lesions in the liver, peritonitis, perityphlitis, periproctitis, perineal fistula, parotitis, erysipelas, rheumatism, neuritis, arthritis, and polyarthritis.

Perforation and peritonitis occurred in 85 out of 580 cases collected by Béranger-Féraud.

Diagnosis.—The recognition of acute dysentery is not difficult if the characteristic symptoms — tormina, tenesmus, and muco-sanguinolent stools—are present. In a case of hemorrhoids blood and mucus are passed, but the hemorrhoidal tumors can be seen, and the discharge follows a normal stool; the blood too is thinner and greater in quantity.

An error of diagnosis is not likely to occur in intussusception, although blood and mucus are passed with straining, but the tumor in the iliac or hypogastric region, the more frequent vomiting and tympanites, and the more rapid collapse are significant symptoms. Sometimes the disease proper may be overlooked when dysentery appears as a complication; this might be the case in typhoid or typhus fever.

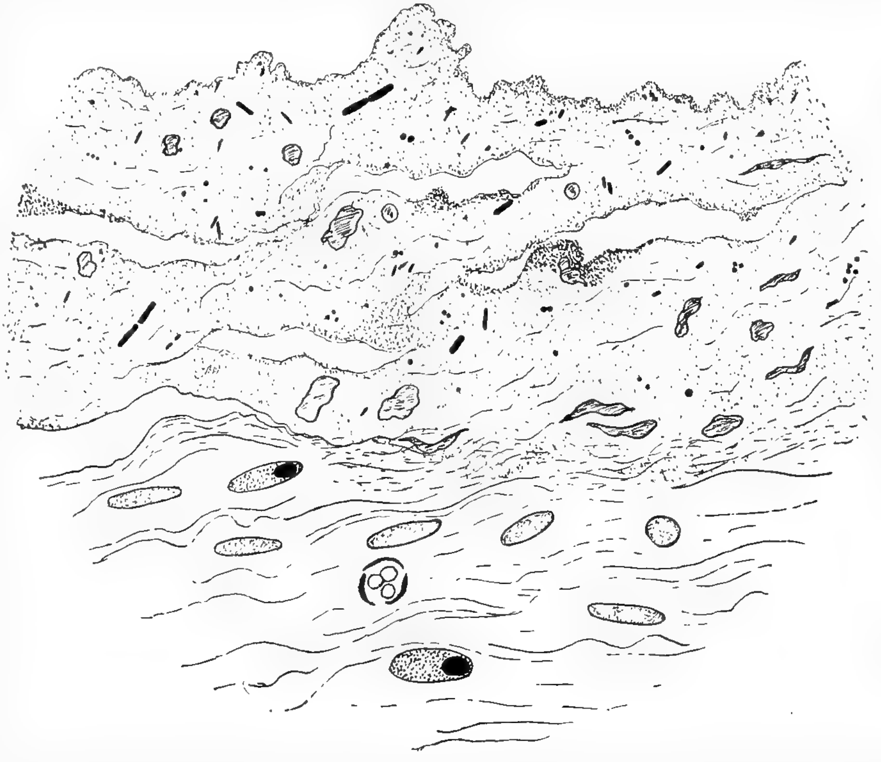

Fig. 1676.—Dysentery Due to Bacillus Dysenteriæ. Bacilli and cocci in superficial necrotic layer. (Methylene blue staining.) Enlarged 500 times. (Section from a specimen in the Army Medical Museum.)

The diagnosis of the nature of the lesion is based upon the general symptoms and the character of the stools. Slight illness and small mucous and bloody stools indicate colitis without infiltration and necrosis; but prostration and serious illness, with larger and more liquid stools, which may be offensive, point to infiltration of the deeper layers of the intestinal wall and to destruction of the mucous membrane. The higher up the inflammation is, the more fluid are the stools; the lower down, the more mucus and blood will be present.

In the future the diagnosis of dysenteric processes will not be complete until their nature is made clear by the discovery of the causative micro-organism in each case. This being known, the nature of the lesion and its progress are matters of certainty; upon this knowledge also the prognosis and perhaps in time the treatment will be based.

The diagnosis will be facilitated by the presence or absence of the agglutinative reaction with the pure culture of the B. dysenteriæ. The same test may be made applicable with other yet undiscovered dysenteric flora.

Prognosis.—The fatality of dysentery varies very much with the conditions under which it appears. The mild form in temperate climates is a self-limited disease, tending to recover spontaneously. It rarely assumes a formidable nature outside the tropics, except when it is epidemic; but destructive epidemics are much more rare than formerly. In England the reduction in the death rate in dysentery has been marked since 1850. In 1880 the mortality was six hundred and sixty-eight times less than it was forty or fifty years before. In the United States the total death rate from dysentery, in 1850, was 20.556, or 6.32 per cent. of the total mortality; in 1860, 10,468, or 2.65 per cent.; in 1870, 7,912 or 1.60 per cent.; and in 1880, out of a total death rate of 756,893, there were 10,825 deaths from dysentery.

The death rate from dysentery in Europe is from six to eight per cent. (Hirsch) of the number attacked. In the garrisons in France there were 7 deaths in 589 cases, or 1.18 per cent. Cases of a higher degree of severity last for from three to four weeks, although complete recovery does not take place for two or three weeks later. In epidemic dysentery death may occur in three or four days, or at the end of the second week, or later.

In individual cases the prognosis depends upon the previous state of health, intercurrent diseases, as scurvy, malaria, etc., and recent residence in the country. Unfavorable symptoms are delirium, distress in the epigastrium, dyspnœa, vomiting, lowering of the body temperature, hiccough, cyanosis, cold skin and extremities, with feeble, rapid pulse, offensive thin or bloody discharges, disappearance of pain with involuntary stools, aphthæ, erysipelas, gangrene of lung, ulcer of the cornea, or suppression of the urine.

In epidemics in temperate climates, the mortality varies from 7 to 15 per cent. From 1841 to 1846, in the epidemics which prevailed in France, one-tenth of those attacked died. In 1836, 1837, and 1838, 25 per cent. died, and in 1857 one out of every five died.

In tropical epidemic dysentery, the mortality is from 20 to 30 per cent. In Bombay it is 9 per cent.; in Hong-Kong, 20 per cent. A mortality of 35 or 40 per cent., and even one of from 60 to 80 per cent. has been reached. In the Manila cases previously referred to, the mortality was 9.4 per cent.

TREATMENT.—The preventive treatment of dysentery consists in avoiding all the known causes, and in living under the best hygienic influences. Measures should be taken looking to the complete drainage of moist soil, the procuring of pure drinking-water, the complete disinfection and removal of all excreta, and the prevention of overcrowding and bad ventilation.

In the treatment of the attack attention should be paid to ventilation and cleanliness, and to the hygienic rules governing the sick-room. With the earliest symptoms the patient should be put to bed (and in a single bed, for greater convenience). The bed covering should be warm, and even in warm weather a blanket should be used, with a view of preventing chilling of the surface by diurnal variations of temperature. The feet especially should be kept warm.

Sponging the surface of the body with cool or tepid water, with vinegar, or with alcohol gives comfort by removing the sensation of burning heat in the skin. The anal region should be carefully and constantly cleansed with a warm disinfectant solution, and anointed with vaseline or other ointment. Hot hip baths have been used with advantage in relieving the tenesmus of dysentery. Hot poultices to the abdomen, or hot fomentations covered with oiled silk, give some comfort to the patient.

The diet best suited to dysentery is one which is digested, as far as possible, in the stomach, and which has but little waste; therefore concentrated broths, or milk, should be given in small quantities at intervals of two hours. Milk may be given pure or diluted with Vichy water, lime water, barley water, or rice water. In the earlier stages of severer cases with high fever, milk should be given in very small quantities, from one to four drachms, every half-hour or hour.

To relieve thirst, mucilaginous drinks, as gum-arabic water, flaxseed tea, the white of egg drink, are advisable. Orange or grape juice is not objectionable, and in cases of scorbutic taint fruit juice, or even fresh fruit, is positively curative.

Alcohol is called for in many cases to sustain the feeble pulse.

Diet alone, or combined with rest, will, in many cases of dysentery, bring about a cure in a few days. In severer cases, although we have no specific, yet drugs are of service in relieving pain and in shortening the attack.

Laxatives.—The laxative method appears so rational that it has gained a firm foothold in popular favor; it is only liable to lose ground by being supported as a "method" and not as an aid to a combined effort to disinfect the intestinal canal by removing contents that irritate mechanically and through chemical decomposition.

If the case is seen early and if the stools are small, consisting of blood and mucus, the treatment can well be begun by a saline laxative, as magnesium sulphate, sodium sulphate, potassium and sodium tartrate, or by castor oil, the dose to be repeated until a distinct effect is produced. In certain cases, especially in children, calomel acts very well and is to be preferred. The presence of hard fæcal matter in the stools and the occurrence of watery fæcal movements are evidences that the laxative has acted sufficiently.

As purgation increases peristaltic movement and irritates the mucous surface, it must, to a certain extent, be harmful in all cases, and is not to be advised if the stools are copious and fluid or if there is much preliminary diarrhœa. The question of repeating the purgative requires some judgment, and it is here that the belief in purgatives as a "method" may do much harm. At the end of a week or later a saline laxative should be given if, with subsidence of the inflammation, there are no natural fæcal movements.

Opium.—The pain and the frequent stools suggest the frequent use of opium, and in moderate doses this drug is of service; the objections to it are the danger of arresting peristalsis completely and causing an accumulation in the bowel of matters that are much better expelled. It is in cases with large, liquid, putrid stools that opiates do positive harm by arresting the discharges. The indications for opium are intense abdominal pain, sleeplessness from pain, or very frequent stools. Dover's powder, deodorized tincture of opium, and morphine hypodermically, are the best forms of administration. For many reasons the last is to be preferred, the doses being sufficient to subdue great suffering and to keep the nervous system in comparative repose. But any effect approaching narcotism should be most carefully avoided by giving small doses at first and at safe intervals afterward.

There is very little to be said in approbation of any other medicine given by the mouth. The treatment by ipecacuanha retains its place in the books, but the Anglo-Indian method with large doses has never had a firm place in the practice of this country, and even its warmest supporters seem to be losing confidence in its value. Small doses of the drug are spoken of favorably, but there is no reason to think that they have any curative effect. The same may be said of the numerous drugs suggested from time to time. Astringents are without effect, and are harmful because they derange digestion. Bismuth in large doses may prove of use, and in any event does no harm.

Antiseptics given by the mouth, although not so efficacious as when injected into the lower bowel, may be employed to supplement their more direct action.

The value of calomel in the treatment of dysentery no doubt resides in its antiseptic properties, and the time-honored combination with Dover's powder has some rational support; but to be of any service the drug should be given in small doses and kept up, in this combination, for several days. Corrosive sublimate in small doses, from gr. $\frac{1}{120}$ to gr. $\frac{1}{60}$ (0.00054–0.0011) every hour, is employed with the same object in view.

Other intestinal antiseptics can be much more readily and thoroughly used by injection and irrigation.

Treatment by Suppositories and by Rectal and Colon Injection and Irrigation.—The use of suppositories containing opiates and astringents, although at one time a common practice, is much less in favor than formerly. It is not desirable to limit to too great an extent the tendency of the rectum to expel its contents. The disease cannot be cured by putting a stop to dysenteric discharges, and therefore suppositories used for this purpose are not to be recommended. After the action of a purgative an opiate suppository may arrest too free purgation and keep the bowel at rest with benefit; after irrigation, also, advantages may, upon the same principle, follow the introduction of a suppository, but the doses of opium should never be large. In attempting to control tenesmus the temptation is frequently to give too large doses, which induce narcotism and which involve danger.

These same rules hold against following the once popular method of using injections of starch water and laudanum, which may be of service with the limitations just mentioned, but as a routine treatment the plan is not to be advised.

The injection into the bowels of large quantities of warm or cold water has many advocates. The sedative effect of water of a high or low temperature upon an inflamed mucous membrane is of undoubted service in dysentery. The only objection is to be found in the danger of overdistending the inflamed gut. Irrigation, by cleansing the ulcerated surfaces, washing away the decomposing contents of the bowel, and destroying bacterial life, gives promise of accomplishing a great deal more than would the mere injection of fluids into the bowel.

Cool or hot water may be used for irrigation, but if an antiseptic agent be added to the water there is an additional benefit.

Antiseptic Irrigation may be practised with solutions of mercuric chloride 1 to 5,000, quinine 1 to 5,000 or 1 to 2,000, salicylic acid, tannin, thymol, carbolic acid, sulphocarbolate of zinc, boracic acid, etc. The use of bichloride solution must always be attended with a certain amount of danger, and precautions should be taken to secure a free exit.

Irrigation can be practised in the rectum or colon; in either case a soft-rubber tube is passed into the rectum or is gently and gradually forced upward through the sigmoid flexure. This is by no means an easy task, as the instrument so readily turns on itself; an occasional examination ought to be made with the finger to see if this has happened. Experiments on the cadaver show that the smaller-sized rectal and colon tubes do not make their way as readily as those of larger size. The habit of injecting water, as the tube progresses, favors twisting; progression is more easily made if the bowel is empty, as the mucus-covered wall guides the instrument in the proper direction. In many cases the colon cannot be reached, and there is danger of perforating the ulcerated bowel if the efforts are continued for too long a time. One must be content, therefore, to pass the tube into the sigmoid. The fluid is then allowed to flow in from a fountain syringe, or is thrown in by a Davidson; when from six to eight ounces have entered, the fluid is allowed to escape through the same tube. This process is repeated until a quart or more has been used, or until the water escapes perfectly clear. If the patient is in the dorsal position or on the left side, with the hips raised, gravity favors the entrance of the fluid. In most cases, and especially in bad cases, with putrescent fluid discharges, it is safer never to attempt to push the instrument beyond the rectum.

The frequency of the irrigation should vary with the number and character of the stools. Large, frequent, putrid stools call for more frequent cleansing of the bowel. If the discharges consist of small masses of blood-stained mucus there is less need of frequent irrigation and less benefit is likely to come from it. As a rule the benefit depends more upon the frequency of the treatment than upon the properties of the antiseptic employed. (See also article on *Enteroclysis*.)

Symptomatic treatment is required for sleeplessness, tormina, and tenesmus, and morphine, to be administered hypodermically, is the most satisfactory remedy. Small doses (gr. $\frac{1}{16}$ to $\frac{1}{8}$) only are safe and these can be repeated at intervals of from two to three hours until some effect is noticed, but great care should be taken to avoid narcotism, to which dysenteric patients are liable.

The strength of the heart can be sustained by strychnine and by nitroglycerin, when called for in emergencies.

Toward the end of the attack solids are harmful when given too early. These should be deferred until the stools have been normal for some days. Rest during convalescence favors a more rapid return of strength.

Great care to avoid exertion and imprudent eating during the convalescence from an acute dysentery, is the best way to prevent the establishment of the chronic forms. If there are evidences of the existence of unhealed ulcers patients should be kept at rest, on a simple diet, for a prolonged period. Colon irrigation with antiseptic solutions or with a solution of silver nitrate, five grains to the pint, is the most rational method of treatment. Sometimes a change of climate is of use.

The treatment of the acute and chronic forms of amœbic dysentery is not invariably satisfactory and often does not appear to have much influence upon the course of the disease. The patient should be kept in bed upon a restricted diet even in the absence of severe symptoms. Warm rectal irrigations with a 1 to 5,000 solution of quinine, which, as shown by Lösch, readily destroys amœbæ outside of the body, should be given two or three times a day, and the patient should attempt to retain the fluid for ten or fifteen minutes. The strength of the solution should be gradually increased to 1 to 500. The corrosive sublimate solution or a solution of nitrate of silver, thirty grains to the quart, may be substituted, but neither of these is so efficient as the quinine, which being absorbed by the tissues undoubtedly destroys the amœbæ embedded in the deeper layers of the intestine.

An antitoxin prepared with Shiga's bacillus by Kitasato in Tokyo is being extensively used in Japan for the cure of bacillary dysentery. No statistics are as yet obtainable, but it is claimed that the results are second only to those of the antitoxin treatment of diphtheria.

William W. Johnston.

DYSIDROSIS. See *Pompholyx.*

DYSMENORRHŒA.—The term dysmenorrhœa (from the inseparable particle δύς, with difficulty, μήν, a month, and ῥέω, I flow) is used in its strict etymological sense, that of painful menstruation; but it should be applied only to menstruation accompanied by severe pain, as distinguished from the moderate aching usually attendant upon the function. Dysmenorrhœa is commonly considered to be only a symptom, and not a disease, and that view is doubtless true of the generality of cases; but in many instances no structural pathological condition can be discovered to account for it, and it may then be looked upon as a neurosis, or perhaps as an expression of the rheumatic diathesis.

Almost all sytematic writers divide dysmenorrhœa into several varieties, founding their division upon what they conceive to be its varying pathology; but a few authors will have it that the affection is necessarily due to obstruction to the escape of blood from the uterus. Those who admit a number of forms of dysmenorrhœa follow a nomenclature intended to express various pathological states, such as the neuralgic, the spasmodic, the congestive, the inflammatory, the membranous, the obstructive, etc.; while others employ names designed to indicate the seat of the fundamental morbid condition, such as constitutional, ovarian, uterine, etc. Both classes of writers enumerate the signs and symptoms by which, as they maintain, the particular forms of the disease may be diagnosticated. Practically, these diagnostic points are not much to be relied upon, and we can only say with certainty: 1. That women who, so far as we can discover, are in perfect health in other respects, both constitutionally and locally, suffer from dysmenorrhœa; although it must be admitted that the great majority of sufferers show evidence of a depraved constitutional state. 2. That women of every sort of systemic ill health escape this ailment. 3. That the affection is found associated with every abnormity of the sexual apparatus. 4. That, except positive occlusion of the uterine canal, there is no condition of the parts concerned that invariably gives rise to it. It will be seen from all this that the relations between dysmenorrhœa and its causes are very diverse and but imperfectly understood, that no single theory of its causation will apply in all cases, and that no one of the nosological systems covers the ground satisfactorily from a clinical point of view. Nevertheless, it is convenient to treat of the affection under some of the various forms that have been assigned to it, whether from pathological or from anatomical considerations.

OBSTRUCTIVE DYSMENORRHŒA.—Obstructive, or mechanical, dysmenorrhœa is that form which is supposed to depend upon an obstruction to the escape of the menstrual blood from the genital passages, either from the oviduct, or from the uterus, or from the vagina. Practically, we may almost restrict it to some impediment to the escape of the blood from the uterus—either an actual stenosis of the uterine canal, a sharp flexure of the organ, or the valve-like action of a polypus, a clot, or an exfoliated membrane. Some years since it was generally held that mechanical obstruction was almost, if not quite, the sole cause of dysmenorrhœa; now, however, the prevailing opinion is that it is only one of a number of conditions that may give rise to painful menstruation, and some authors go so far as almost to deny the possibility of stenosis causing dysmenorrhœa. Each of the extreme views mentioned is untenable; undoubtedly there is such a thing as obstructive dysmenorrhœa, but it is the exception rather than the rule.

The diagnosis of obstructive dysmenorrhœa should not be made from the rational symptoms, however plausible it may sound to say that, in a given case, the pain is paroxysmal, each paroxysm being followed by an escape of blood, liquid or clotted, and that therefore the retention of that blood in the uterus was what caused the pain. The blood may simply have been retained in the vagina, and cast out as the final step of a spasmodic exacerbation; moreover, many sorts of pain are paroxysmal quite irrespective of their cause. Excepting the temporary obstruction that may result from spasmodic or congestive narrowing of the uterine canal, we should diagnosticate uterine stenosis only after a physical demonstration of its presence. If the condition known as "pinhole os" is observed; if a small probe cannot be passed into the cavity of the body of the uterus, or can be so passed only with great difficulty (especially with the patient anæsthetized); if a sharp flexure of the uterus is detected; or if an intra-uterine growth is found so situated as readily to occlude the canal, we may reasonably conclude, in the absence of any other discoverable cause, that the pain is due to obstruction. It will not do to infer positively from the good results of mechanical treatment that the trouble was caused by obstruction, for we know too little of the collateral effects of such treatment to limit its action to so narrow a field.

The treatment of obstructive dysmenorrhœa is directed, of course, toward overcoming the obstruction. The treatment of flexures and polypi of the uterus will be found in the sections of this work which are devoted to those affections, and we have here to deal only with the uterine canal. The procedures that have been practised for the relief of uterine stenosis include dilatation, divulsion (the so-called rapid or "bloody" dilatation), and various cutting operations. Dilatation by means of expanding tents is generally regarded as too temporary in its effects to be considered curative, and too dangerous to be resorted to repeatedly as a palliative. The tupelo tent, however, is less objectionable on the latter score than the sponge tent, and the tubular tupelo tent, as recommended by Dr. Sussdorf, of New York, is perhaps to be regarded as reasonably free from danger as a palliative. Dilatation by means of graduated metallic or hard-rubber sounds is safer than the use of tents, and some authors report excellent results from their use. A certain amount of force is allowable in the passage of these sounds, counter-pressure being made upon the uterus through the abdominal wall or (less to be recommended) traction upon the cervix with a tenaculum. Still greater success has been stated to have been achieved with divulsion, especially by the late Dr. Goodell, of Philadelphia, whose experience with the method was very great. Dr. Goodell preferred an instrument so constructed that the blades remained parallel when they were separated, and had transverse grooves on the outer surface of each blade, to prevent the instrument from slipping out during the operation.

In regard to cutting operations in cases of stenosis at the os externum, a simple bilateral nicking is sufficient, and this is a procedure much practised by some gynecologists, who hold that the stricture is generally at that situation. Others prefer discission (bilateral incision) of the whole length of the cervical canal, which they accomplish by means of special instruments—metrotomes, or hysterotomes—consisting either of a forceps-like mechanism, the blades, furnished with an outer cutting edge, being introduced closed and withdrawn expanded, or of a stem upon which a blade is slid into the canal. Many operators insert a glass or hard-rubber plug after the incision has been made, to maintain the calibre of the canal. In cases of flexion, especially anteflexion, some practitioners prefer the more radical operation devised by the late Dr. Marion Sims, for a description of which the reader is referred to the heading *Uterus, Diseases of.*

Inasmuch as cases of obstructive dysmenorrhœa constitute the minority, the successful treatment of the affection covers a far wider range than that of overcoming mechanical impediments, and even in cases that appear to be mechanical, palliative treatment is sometimes all that the patient will submit to. The first indication is to remedy any defect of the general health so far as possible. The subjects of dysmenorrhœa are apt to be anæmic, and the sensitiveness of their nervous system is commonly excessive. Careful attention to hygiene and the use of such nutritive tonics as cod-liver oil, iron (preferably in conjunction with an alkali, as in Blaud's pills), and especially arsenic, are among the measures on which the chief reliance is to be placed. What is known as "general faradization" is a valuable adjunct. Any abnormal condition of the generative organs that can be discovered should be made the subject of treatment; those that most frequently give rise to dysmenorrhœa being the remains of inflammatory exudates which cripple the uterus by preventing its physiological increase in volume during menstruation, interfere with the ready return of blood from it, or draw it into some unnatural posture or configuration. It is not rare for a prolapsed and tender ovary to be found as the accompaniment of dysmenorrhœa. The management of the various abnormities that may give rise to the affection will be found treated of in other sections of this work.

Membranous dysmenorrhœa is a variety *sui generis.* Its pathology is not well understood. In this form the superficial part of the endometrium is cast off more or less entire at each menstruation, constituting the so-called *decidua menstrualis,* instead of undergoing the natural process of molecular disintegration. The causes of this phenomenon are wholly unknown, and the explanation of its relation to the pain is made doubly difficult by the fact that this exfoliation *en masse* is not always painful. Membranous dysmenorrhœa is a particularly rebellious form of the disease, and severe measures have often been resorted to unsuccessfully for its relief. Success has been attained by the application of strong nitric acid to the endometrium, and it has also followed the use of a great number of other applications. The late Dr. Skene, of Brooklyn, acquainted the profession with his very encouraging results from applications of iodoform, which he credits the late Dr. Fordyce Barker with having been the first to use in this country.

As regards the palliative treatment of dysmenorrhœa, a cardinal point should be to avoid the use of narcotics, except on occasions of special urgency, in order that the patient may not acquire the habit of resorting to them. If possible, the sufferer should maintain the recumbent posture, or at least abstain from active bodily movements, for three or four days before the flow begins, and during its continuance. During this period, especially if the flow is excessive in amount, or if there are signs of undue pelvic congestion, a hot-water bag or flannels wrung out of hot water should be applied over the junction of the dorsal and the lumbar portions of the vertebral column four or five times a day, for ten or fifteen minutes at a time. The use of hot aromatic drinks is a popular remedy, and one that is not by any means to be despised; but the resort to gin, which is far too common, should be discountenanced. Some such preparation as the parsley water of the Germans may be substituted. Local anodynes are best administered in the form of rectal suppositories. A suppository containing five grains of iodoform, with or without a sixth of a grain of extract of belladonna, is very efficient; opium should be used only in case of actual necessity. Many drugs prove of service when given by the mouth, but they are apt to lose their efficiency after a few periods, and this is a strong argument in favor of the neurotic nature of the affection in many instances. One of the most trustworthy is the *Viburnum opulus*, in the form of five grains of the abstract every three hours, during the painful part of the period. The passage of the faradic current through the pelvis two or three times a week, during the intermenstrual period, is often of service. Apiol, a preparation made from parsley, has been used by many practitioners with success. It is commonly given in the form of capsules. Potassium permanganate was extensively used a few years ago, but is not now often resorted to. Several of the synthetical anodynes are valuable in the palliative treatment of dysmenorrhœa, especially antipyrin. Recent reports make it probable that "stypticin" (cotarnine hydrochloride) is the most efficient of them all. Two-fifths of a grain, in a gelatin capsule, may be given four or five times a day for five days preceding the flow, and double that dose, repeated at like intervals, during the first few days of the flow.

Frank P. Foster.

DYSPEPSIA. See *Stomach, Diseases of.*

DYSPHAGIA (*δυς-φάγω*).—Difficulty in swallowing, or in deglutition.

Any impairment of the normal process of deglutition may give rise to dysphagia. Such impairment may be organic, and due either to structural lesion or to surgical derangement, or it may be functional, from direct or reflex neurosis. The organic derangements which most frequently cause dysphagia are: acute inflammatory, tuberculous, cancerous, syphilitic, and diphtheritic affections of the mouth, pharynx, tonsils, larynx, and œsophagus; affections of the salivary glands, and retropharyngeal abscess. In diseases of the spleen, dysphagia may arise from secondary lymphatic hyperplasia of the tonsils and the follicles of the pharyngeal mucous membrane.

In pressure diverticula or sacciform dilatations of the œsophagus, also, this symptom is present. Again, it may be caused by direct pressure of a thoracic aneurism upon the œsophagus, or by that of a malignant new growth located in the pleura or in the posterior mediastinum.

The surgical causative conditions are operations upon, and injuries of, the mouth, tongue, superior and inferior maxillary bones, soft and hard palate and uvula, tonsils, pharynx, larynx, and œsophagus. The neurotic conditions most commonly met with are: spasm of the pharyngeal constrictors, paralysis of the velum palati or of the pharynx from some cerebral lesion or as a sequel of diphtheria, general paralysis of the insane, progressive muscular atrophy, glosso-laryngeal paralysis, hysterical affections, and, finally, in rare cases, a pharyngeal neurosis of apparently reflex origin. As instances of the latter character may be mentioned those cases in which the spasm occurs in angina pectoris (due probably to the numerous connections between the sympathetic and the vagus), or in pericarditis, not only when the exudation is large enough to cause direct pressure upon the œsophagus, but also when there is only a small amount of exudation present.

The disastrous effects of dysphagia will be proportionate to the severity and duration of the cause. While the latter must, of course, largely determine the plan of treatment to be adopted in a given case, there are, nevertheless, certain facts which must be borne in mind when an attempt is made to formulate the measures that should be adopted. Thus, for example, it must be remembered that in conditions which are attended with dysphagia, the act of deglutition will produce pain, either local or reflex, or mechanical or chemical injury to parts already inflamed or ulcerated, or both. These, and especially the first, not only by interfering with the ingestion of food, but also by the depressing effect upon the nervous system of frequently recurring pain, may result in impairment of nutrition. The general indications to be met would be, therefore, the securing of rest to the parts, and the avoidance of causes which excite pain; protection of the parts from mechanical or chemical injury; and the maintenance of nutrition.

It is obvious that the above ends must be met by the administration of highly nutritious food, reduced to so small a compass and rendered so unirritating that it can be ingested with the least discomfort and with the fewest acts of deglutition. Thus, in tuberculous or cancerous affections the patient, unable to manage either solids or liquids, will often swallow with success an unbeaten raw egg, a small unseasoned raw oyster, lumps of rennet custard, or some such semi-fluid and yet coherent bolus. The local pain may be temporarily relieved in many instances by the application of morphine, cocaine, eucaine, orthoform, or, in some cases, of menthol.

These means are, however, in a large majority of instances inadequate to fulfil the necessary conditions of rest, avoidance of pain, and of injury to the parts, and are, moreover, totally insufficient for the proper nutrition of the patient. In many chronic cases pain and local irritation undergo a steady augmentation, and, in the unequal struggle for life, enough food not being taken at any one time to supply the demands of nature, the patient surely and steadily loses ground. In acute affections of the throat all nourishment will sometimes be declined until the severity of the attack has subsided, thus adding to the enfeeblement caused by the disease itself, and protracting the period of convalescence; while in the surgical conditions above referred to the evils of dysphagia are sufficiently evident.

Since the act of deglutition is the immediate cause of dysphagia, the most rational means for relieving the dysphagia would be, obviously, to remove the cause; in other words, to abolish the act of deglutition. This may be accomplished in the following ways;

1. When there exist both dysphagia and inability on the part of the stomach to retain food, an invaluable resource lies in rectal alimentation, the utility of which has been so well established that it is only necessary, in the present connection, to call attention to the importance of its adoption early in the history of the case, and before the strength of the patient has been reduced by want of food.

2. When, on the other hand, the condition of the stomach is good, then, granting the desirability of alimentation by way of the natural passages, the indication is clearly to remove the obstacle to deglutition or to avoid it. The former may be impossible. The latter, however, may be accomplished in a large number of cases by the use of an œsophageal tube, through which nutritious food, in liquid form, may be injected into the stomach. The best means for accomplishing this purpose are: (1) the employment of a tube of the smallest possible calibre, and (2) the introduction of this tube, not necessarily into the stomach, but merely into the œsophagus and past the point of obstruction, or else past the pharyngeal constrictors. Through the tube the stomach may be made to receive food in unlimited amount and variety, without any attempt at deglutition, and with perfect protection to the parts. By this device all of the indications mentioned may be met. The apparatus needed is simple, the essential part of it being an English flexible woven catheter, an open-ended soft-rubber catheter, or a small œsophageal tube, attached by means of a piece of rubber tubing to a receptacle for the food. For the latter a glass funnel will be found convenient.

To the great advantage of the catheter over the large and clumsy stomach tube it is hardly necessary to refer. Its introduction is much less startling and uncomfortable to the patient, and, if the food be properly prepared, highly concentrated preparations being employed, after the manner of Debove, the large tube will be unnecessary. As a general rule, the irritation caused by the passage of the tube increases with its size. The tube should be introduced in the usual manner; that is, the patient's mouth being opened and his tongue protruded, the catheter should be carried to the base of the tongue, then the patient should be told to swallow, and, as he does so, the catheter should be pushed into the œsophagus, and thence downward as far as may be deemed necessary. The larynx may be avoided with certainty by using the finger as a guide. Before its introduction the tube should be carefully lubricated, for which purpose white of egg, mucilage, or even milk, are useful. An excellent plan is to allow the patient to swallow slowly, just before the introduction of the catheter, a drachm or two of pretty thick mucilage. Vaseline, glycerin, and oil are unpleasant to the patient and should on no account be used. In passing the catheter gentleness should be observed, and great care taken to avoid, as far as possible, all points of special tenderness. In many cases the patient himself may be taught to pass the tube much more successfully and comfortably than it can be done for him, since the manœuvre is not difficult, and no one knows so well as the patient the exact situation of the painful spots. Sometimes, especially with children, the point of greatest irritability is in the palatine arches, and any attempt at passing a tube across them will be followed by violent gagging. In such cases a soft-rubber tube may be passed through the nostril and pharynx, and thence into the œsophagus, and thus contact with the fauces be wholly avoided. Should the introduction of the tube cause dyspnœa, direct the patient to take full breaths. The instrument may also cause nausea when it passes the pharynx, and for the relief of this Dujardin-Beaumetz advises the administration of bromide of potassium; and then again it may cause nausea when it reaches the stomach, in case it be inserted so far. In the latter case, however, the introduction of food will quickly bring relief.

Of course, the passage of the tube will not always prove an easy or a painless operation. A little practice, however, will render it possible in nearly every instance, while the advantages to be gained far outweigh any ordinary objection to the method.

As to the special conditions in which dysphagia will call for relief, the reader is referred to the various articles, in other parts of the Handbook, in which these subjects are discussed. *D. Bryson Delavan.*

DYSPNŒA.—Dyspnœa is a striking symptom of a vast variety of diseases, at times very simple of interpretation, at other times requiring a comprehensive knowledge of physical diagnosis, clinical diagnosis, and the symptomatology of disease, in tracing it to its cause. It is a symptom which stimulates careful efforts in differential diagnosis, since it is very seldom that it can be relieved unless its causal disease be correctly diagnosed and treated. Pain, on the other hand, is a common symptom which can usually be relieved without a diagnosis of the causal disease. The object of this article is to impress upon the general practitioner the importance of careful and time-consuming examinations, and to assist him in tracing this particular symptom to its cause. In my work I have examined patients suffering with extreme dyspnœa whose cases had been diagnosed renal asthma because albumin had been found in the urine, and cardiac asthma because of irregular pulse and cardiac murmurs. In both cases examination of the chest and aspiration showed that the dyspnœa was to a large extent dependent upon extensive hydrothorax, which was secondary to the cardiac and renal disease. In adult life diseases of the lungs and pleuræ, heart and kidneys, are the most common causes of dyspnœa, while in childhood diseases of the naso-pharynx, larynx, trachea, and bronchi play this rôle.

We must distinguish between simply increased breathing (over twenty-four respirations in the minute) and difficult or hindered breathing, *i.e.*, dyspnœa. The former is found in emotional and hysterical conditions, after exertion, and in fever. Dyspnœa bears about the same relation to normal breathing that palpitation of the heart does to the normal action of the heart. In health and when not undergoing exertion, we are unconscious of the action of the heart and practically so of the act of respiration. When conscious of the forcible or irregular action of the heart, whether the rate be normal or increased, palpitation is present. In dyspnœa one is usually conscious of distress. The alæ nasi move, there is forcible movement of the chest, and the auxiliary muscles of respiration are brought into action proportionate to the degree of dyspnœa. The respirations may be normal in rate, but deeper than usual, or they may be increased in frequency and shallow, or they may be both increased in frequency and in depth.

Dyspnœa may be continuous or paroxysmal. Again, it is either inspiratory, expiratory, or mixed, depending upon the cause. It may be so severe as to compel the upright position, when it is termed orthopnœa. It may be associated with peculiar alterations in rhythm and strength, when it is termed the Cheyne-Stokes type of breathing. Dyspnœa may be accompanied by peculiar sounds as in laryngismus stridulus, hysteria, inflammation of the larynx, Cheyne-Stokes breathing, and pneumonia. Dyspnœa with cyanosis is a very important symptom, pathognomonic of incompensated heart disease or advanced lung disease; in rare cases abdominal disease which interferes with the action of the diaphragm causes this type of dyspnœa. The character of the dyspnœa is in some instances indicative of the nature and location of the disease causing the obstruction. Inspiratory dyspnœa is caused by a stenosis of the upper air passages, the result of inflammatory conditions, growths, or spasmodic contractions. Expiratory dyspnœa is caused by the presence of a tumor, usually in the larynx, which acts like a valve, being forced up against the glottis during expiration. In emphysema and asthma the expiratory form of dyspnœa predominates. The mixed type, involving both inspiration and expiration, is found in diseases of the heart and blood, lungs and kidneys.

In the dyspnœa of childhood it is very important to know whether the obstruction is located in the larynx or in the trachea, as upon it depends the decision between intubation and tracheotomy. If the obstruction be in the larynx, it is seen to rise and fall during respiration. If the dyspnœa is severe the head is bent back, the neck is stretched, the muscles of the neck are contracted, the spaces above the sternum and at the side of the trachea are drawn in with each inspiration, the alæ of the nose work vigorously, and there is a change in the voice. If the dyspnœa is from stenosis of the trachea, the larynx is not markedly moved during breathing, and the patient bends the head forward rather than backward. There is no change in the voice except that it may be weakened.

Causes of Dyspnœa.—Musser gives the following classification: 1. Anything cutting off or lessening the normal amount of air required for oxygenation of the blood. 2. Affections which lessen the amount of blood. 3. Affections in which red corpuscles are diminished. 4. Pulmonary embolism and thrombosis. 5. Fat embolism. 6. Interference with the nervous mechanism of respiration.

1. (*a*) *Obstruction of the Air Passages.*—Under this heading we find many of the common causes of dyspnœa in children, such as occlusion of the nares and naso-pharynx, especially by adenoids, unless compensated for by mouth breathing. The importance of examining suspicious cases for adenoids and instituting the proper treatment cannot be overestimated. Enlarged tonsils, retro-pharyngeal abscess, or any obstruction in the throat, such as diphtheritic swelling, may cause dyspnœa.

Dyspnœa is one of the most common symptoms of laryngeal disease. Its causes are: (1) constriction by inflammatory or œdematous swelling; (2) spasm; (3) tumors or foreign bodies in the larynx; (4) cicatrization of ulcers after syphilis or lupus; (5) paralysis of abductors or adductors of the larynx.

Pressure on the larynx producing dyspnœa may be caused by cellulitis of the neck, tumors of the lymph glands, goitre, and retro-pharyngeal abscess. It should be remembered that in diphtheria dyspnœa may be due to pressure of enlarged glands on the larynx or bronchi. Sudden œdema may occur in syphilitic and tuberculous ulceration, and may kill the patient. I have recently seen a patient with leukæmia die from the sudden development of œdema of the glottis.

Pressure on the trachea and bronchi causing dyspnœa may be exerted by tumors of the thyroid gland, by thoracic aneurism, by mediastinal tumors, by cancer of the œsophagus, and in rare cases by dilated auricle; foreign bodies and diseases of the walls, and syphilis, also cause dyspnœa.

In the dyspnœa of bronchial obstruction, which may be caused by the pressure of an aneurism, the laryngeal movement is not increased and the voice is not changed. The physical signs over the lung of the obstructed bronchus become pronounced.

(*b*) *Diminution of Air Space from Causes Within and Outside of the Thorax.*—This division is very large and includes the most common causes of dyspnœa in adults, namely, the numerous acute and chronic diseases of the lungs and pleura, such as the various forms of tuberculosis, acute and chronic, different forms of pneumonia, capillary bronchitis, pneumothorax and empyema, emphysema, asthma, new growths in the lungs and pleura; the various forms of pleurisy, with effusion and chronic dry with adhesions; pericarditis with effusion, acting like pleurisy with effusion, with the additional factor of greater interference with the action of the heart.

The extra-pulmonary causes which diminish the air space are chiefly diseases below the diaphragm, ascites, tympanites, and ovarian tumors.

The severity of the dyspnœa is strikingly dependent upon the suddenness with which the cause acts. It is a case of adaptation, and the development of compensation. In pleurisy with the rapid formation of a large effusion, or especially in certain forms of pneumothorax, dyspnœa is at first alarming; while in a chronic pleurisy or in an advanced tuberculosis which has been months or years in developing, and in which a much larger air space is involved and rendered useless, there may be no dyspnœa except on exertion.

(*c*) *Interference with the Action of Muscles.*—This may be the result of weakness, paralysis, pain, or tetanic contractions, as in hydrophobia and tetanus. Obesity, myxœdema, œdema, trichinosis, and myositis may interfere with the action of the respiratory muscles. Paralysis of the phrenic nerve causes an interesting form of dyspnœa. There is marked interference with the action of the diaphragm, with the result that during inspiration the epigastrium and the hypochondriac regions are drawn in, and during expiration pushed out, the reverse of the normal phenomenon.

Pain, due to disease of the pleura, muscles, or intercostal nerves, or due to conditions below the diaphragm, may cause dyspnœa.

2. *Affections which Lessen the Amount of Blood,* as obstructive heart diseases, and (rarely) tumors pressing upon blood-vessels. Dyspnœa due to heart disease is nearly always associated with cyanosis. It is clinically divided into (1) dyspnœa caused or increased by exertion; (2) paroxysmal dyspnœa; (3) orthopnœa; (4) rhythmical dyspnœa or Cheyne-Stokes respiration.

The dyspnœa of effort comes on after the slightest exertion. In paroxysmal dyspnœa the attack comes on without apparent cause. It must be distinguished from the paroxysmal dyspnœa of uræmia, asthma, or emphysema. The physical signs of lung disease usually point to the latter. The paroxysmal dyspnœa of heart disease is attended by more violent efforts in breathing than the physical state of the lungs admits, and the difficulty attends both inspiration and expiration. Wheezing is not so marked as in forms of asthma. There is some obstruction to the out-going air, but, on account of air hunger, all of the efforts of the patient are exerted to fill the chest. In paroxysmal dyspnœa the breathing usually becomes quiet if the patient is placed in a comfortable position, provided there is no lung or pleura complication. The position does not modify the severe dyspnœa of asthma or emphysema.

3. *Affections in which Red Corpuscles are Diminished.*—In the various anæmias, primary and secondary, even with a very low blood count, the patient does not suffer with dyspnœa while resting. Slight exertion, walking, or climbing stairs, brings on labored breathing. Cyanosis is not usually associated with this variety of dyspnœa.

4 and 5. *Pulmonary Embolism and Thrombosis* are rare causes of dyspnœa. Weak hearts favor their development. A clot may be dislodged from a uterine sinus after labor, or a clot resulting from inflammation of the veins in any location may be carried to the lungs, and completely block a larger or smaller pulmonary vessel. Fat embolism occurring in parturient women three or four days after labor, in fractures, and in diabetes, acts in the same way.

6. *Interference with the Nervous Mechanism of Respiration.*—The possibility of tumors, hemorrhage, or degeneration about the respiratory centre must be kept in mind. The history and the exclusion of other conditions by careful examination will aid in the diagnosis. The irritation of the respiratory centre by toxic agents in the blood, as in uræmia, diabetes, auto-intoxication from gastro-intestinal disorders, and warm blood in fevers, is a very important cause of dyspnœa. A routine examination of the urine will prevent many mistakes in diagnosis.

CHEYNE-STOKES BREATHING.—Modifications of the breathing are among the important symptoms of uræmia. A common type in the uræmia of chronic nephritis is the Cheyne-Stokes breathing. It is a form of periodic respiration, very interesting and important as a bad prognostic sign. It is seen most commonly in apoplexy, tumors of the brain, meningitis, incompensated heart diseases and toxic conditions, such as uræmia, morphine poisoning, acute infectious diseases, especially typhoid fever, and in acute diffuse peritonitis. The patient is usually stupefied or comatose.

In this form of breathing there is a cycle consisting of two periods of nearly equal length. The period of apnœa, during which there is not the slightest respiratory effort, lasts a variable length of time, from a few seconds to two minutes. This is followed by the period of active respiration, which I have observed to be a few seconds longer than the period of apnœa. A very faint, scarcely perceptible, sighing respiration first occurs; this is followed by gradually increasing and deepening respirations, till in marked cases abnormally deep and loud respirations, accompanied by snoring or groaning sounds, are taken. The respirations now gradually decrease in strength, running down the scale, till the period of apnœa is again reached. This cycle may be repeated for several days or even for weeks or for months.

In one of my cases of apoplexy the patient was completely comatose during the period of apnœa, but, as the respirations became deep, he roused himself sufficiently to groan and ask questions. The number of respirations in each cycle varies; most often there are from eight to twelve following each other in about normal celerity, but at the beginning and end of the period they are sometimes somewhat slower. Occasionally there are, besides some secondary symptoms, regular contractions of the pupil during apnœa, and dilatation of them at the height of respiration, and retardation of the pulse during apnœa. Sahli has observed that the patients become cyanotic at the beginning of respiration and that the cyanosis increases till the height of respiration is reached, which corresponds with the conduct of the pupils.

The cause of Cheyne-Stokes breathing is supposed to be an alteration in the function of the respiratory centre. The theory is that there is a periodic diminution in the excitability of the respiratory centre, or that the excitability of the medulla oblongata becomes exhausted. *Biot's respiration* is probably a modification of Cheyne-Stokes breathing, with the same significance.

Pulmonary symptoms are quite common in uræmia; in fact, spasmodic dyspnœa is the first and sometimes the only symptom for a long time. Later, the renal symptoms become pronounced, pointing to the nature of the disease.

DYSPNŒA IN SPECIAL DISEASES.—*Asthma* is a form of paroxysmal dyspnœa, dependent most often upon nasal, bronchial, and gastro-intestinal reflexes. It is a striking picture of air hunger, and suggests the following alteration in the lines from "The Ancient Mariner, "Air, air everywhere and not a bit to breathe." There are diminished respiratory movement and prolonged expiration. The frequency of respiration is diminished sometimes to one-half the normal rate; the rhythm is altered, inspiration is short and gasping. A natural consequence of an asthma of long duration is the advent of *emphysema*, when the dyspnœa becomes more constant. The dyspnœa is proportionate to the degree of emphysema and is aggravated by the coexistence of bronchitis, asthma, and eccentric hypertrophy of the right ventricle (which are frequent complications in long-standing cases). When emphysema is only moderate, dyspnœa is not complained of, except on climbing or walking briskly, or after a hearty meal, but when it is great, the dyspnœa is constant, interferes with all exertion, frequently necessitates orthopnœa and prevents continuous speech.

In *Aortic Aneurism* and mediastinal tumors, dyspnœa is a frequent symptom, and is due chiefly to pressure.

In *Capillary Bronchitis* of infancy, respirations may be as many as 60 to 80 per minute. Dyspnœa is more or less constant, but becomes urgent in paroxysms, and the patient may have to be propped up in bed to breathe. It is expiratory. Inspiration may be free and easy or difficult, but expiration is always difficult and prolonged.

Gastric Disease.—Dyspnœa occurs in many cases of dyspepsia, if the subject is the victim of asthma, anæmia, or cardiac disease. In asthma it is usually reflex. In anæmia it is due to atony of the stomach and gaseous accumulation. In cardiac disease it is mechanical, from the pressure of a stomach distended with gas.

In *Hydrophobia*, the spasmodic contraction of the larynx may become so strong as to excite urgent dyspnœa, with the emission of curious sounds.

Hysteria sometimes explains obscure cases of dyspnœa. Such cases have been reported by physicians of the German army. In the fall of 1898 a soldier entered the University of Michigan hospital, suffering with a continuous dyspnœa, so severe at times that it compelled the orthopnœic position. Very careful physical and clinical examinations failed to reveal any adequate cause for the dyspnœa. It was perhaps hysterical.

In *Nephritis* dyspnœa may be a pronounced symptom, due either to uræmia or to œdema of the glottis, to effusions into the pleura, or to bronchitis. If dilatation of the heart occurs, dyspnœa may arise, due to that or the secondary œdema of the lungs.

In *Phthisis* dyspnœa is almost constant. The degree varies with the association of fever; when the latter is present, dyspnœa is more pronounced. It is also more pronounced in acute cases. In miliary tuberculosis the frequency of respiration is out of all proportion to the physical signs. In this form cyanosis is more marked. In chronic localized phthisis the dyspnœa may occur only on exertion, after eating, or upon excitement. In later stages the dyspnœa is constant and in proportion to the extent of involvement of the lungs and the degree of fever.

In *Pneumonia* frequent respirations—40 to 60 in adults, 60 to 90 or more in children, per minute—is a characteristic symptom. It is panting in character, particularly when pneumonia occurs in old subjects; both inspiration and expiration are brief, though sometimes separated by a rather long pause. Expiration is usually accompanied by an audible grunt, indicating great oppression. Dyspnœa may be absent, or, as the case progresses, may become either increased or greatly diminished, according to the severity of the type.

The chief causes of dyspnœa in pneumonia are involvement of lung, bronchitis, pericarditis or extensive pleurisy, cardiac failure, collateral congestion with œdema, *fever*, and the intense pain in the side. That, in a frank case of pneumonia, irritation of the respiratory centre by toxins or warm blood, is the chief cause of dyspnœa, and not the lung involvement, is proved by the fact that synchronous with the crisis and the fall of temperature (while the consolidation of the lung still exists) the dyspnœa disappears.

In *Pneumothorax* developing in the course of a tuberculosis, severe dyspnœa and frequently cyanosis, are among the first symptoms. The difficulty in breathing is often accompanied by a sense of impending suffocation. The stress of the dyspnœa depends upon the amount of air that suddenly gains entrance into the pleural cavity. If the orifice be large and valvular, the air cannot escape and rapidly accumulates, and forces all of the air out of the lung by compression, and the respirations become frequent, 60 or more per minute.

In *Tetanus*, thoracic oppression, dyspnœa, and more or less cyanosis follow interference with the respiratory function, especially if there is spasm of the glottis.

The treatment of dyspnœa is the treatment of the various diseases with which it is associated.

James Rae Arneill.

EAR: ANATOMY OF THE TYMPANIC MEMBRANE AND OSSICLES.

—The tympanic membrane, membrana tympani, or drum membrane, is composed of three layers: viz., the external or dermoid layer, the middle or fibrous, and the inner or mucous layer.

The dermoid or skin layer of the membrana tympani is a continuation of the skin of the external auditory canal. In this layer, however, there are no hairs nor follicles, as are found elsewhere in the cutis of the auditory canal. In other respects it is true skin, but extremely thin and transparent. The outer or skin layer of the membrana tympani is the only one of the three component layers of the drum membrane which can be inspected directly from without. When the auditory canal is illuminated and a normal membrana examined from without, several prominent features in it attract the observer's attention: viz., its almost circular shape, and peculiar polish and color; its vertical and horizontal inclinations; the ridge formed in one of its radii by the handle of the hammer bone; the short process at the upper end of the latter; the folds of the membrana; the flaccid portion of the tympanic membrane, the portion above the short process of the hammer, the so-called Shrapnell's membrane; the white, tendinous periphery of the membrane; and, finally, the bright, triangular reflection of light in the antero-inferior quadrant of the membrane, running from the lower end of the malleus, at the centre of the membrane, the umbo, toward the periphery. This reflection is called the "pyramid of light" (see Fig. 1678). Generally a delicate plexus of vessels can be seen in the region of the folds and in the membrana flaccida, and one or two delicate arterioles can be traced downward along the manubrium of the malleus.

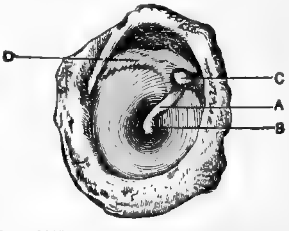

FIG. 1677.—View of Outer Surface of Membrana Tympani. (Gruber.) *A*, malleus, manubrium; *B*, lower end of manubrium; *C*, short process; *D*, posterior fold of the membrana.

For purposes of convenient description, the membrana tympani is called circular in shape. Its form, however, varies between that of an ellipse and an irregular oval, while in some cases, in which the lateral portions of the *annulus tympanicus* are especially curved outward, it assumes a heart shape. Strictly, it may be considered an ellipse, the long diameter of which, amounting to 9 or 10 mm., runs from above and in front downward and backward, and the shortest diameter of which runs from below and in front, upward and backward. The proportion between these diameters is 4.3''': 4.0''' (Von Troeltsch and Hyrtl). Since the difference between them is so slight, and their inclinations are so nearly vertical and horizontal, the outline of the tympanic membrane is considered circular, and is divided into quadrants by the horizontal and vertical diameters, which greatly aids in locating points to be described.

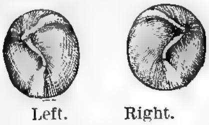

FIG. 1678. — The Normal Membrana Tympani.

Color.—The normal color of the membrana tympani is not constant, because it varies, just like the color of the teeth, with the individual. As the latter varies from a bluish to a yellowish-white, so the drum membrane varies, in a perfectly normal condition, from a bluish to a yellowish-gray, the former being the commoner tint. This color is generally spoken of as a "pearl color," but, whatever color the tympanic membrane possesses, it is always modified by the physical conditions incident to stretching a nearly transparent membrane over a darkened cavity.

The color of the membrana tympani is furthermore modified by the color it transmits from the tympanic cavity, the latter factor being modified by the varying degrees of tenuity of the membrana, as well as by the varying conditions and colors of the mucous lining and the contents of the tympanic cavity. That part of the membrana tympani behind the lower end of the manubrium, and over the promontory of the cochlea, is rendered yellowish-gray by the rays of light reflected from this part of the inner wall of the tympanic cavity.

The membrana tympani owes its peculiar lustre to the delicate and shining epithelium of the skin layer. The slightest máceration, exfoliation, or thickening of this delicate epithelium deprives the membrane of its beautiful gloss. The dermis of the membrana is thickest in children, and hence their membranæ rarely shine as brightly as those of adults.

The Inclinations.—Another important feature attracting the eye of the observer is that the membrana tympani, in its normal condition, is inclined outward in its vertical plane at an angle of 45°, and in its horizontal plane ten degrees toward the right on the right side and ten degrees toward the left on the left side. If the planes of both membranæ be extended downward until they intersect, the angle they will then form will be equal to from 130° to 135°. Of still greater importance than this, however, is the direction of the walls of the auditory canal from the plane of the membrana tympani. Thus if a perpendicular be drawn from the upper pole of the drumhead to the inferior wall of the auditory canal, it will strike the latter about 6 mm. from the inferior pole of the membrane. A similar result will be obtained by drawing a perpendicular from the middle of the posterior periphery of the drum membrane to the anterior wall of the auditory canal, from which it is manifest that the lower anterior part of the membrana is farther from the external opening of the canal than the posterior upper part is. The membrana tympani is inclined the most in very young children, being almost horizontal in the early years of life. As the osseous canal does not exist at this early period of life, the upper part of the membrana tympani lies very near the external meatus at this time.

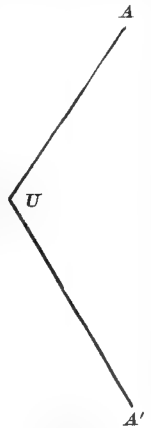

FIG. 1679.

In some instances there is observed a physiological variation in the obliquity of the membrana tympani, and a filling in of the segment of Rivinus (the region of the membrana flaccida) with osseous tissue. Hence on inspection it is found that a large portion of the field at the fundus of the canal is taken up by the upper wall of the canal, which seems to dip down to join the membrana tympani on a line with its folds. In such cases there is very little or no membrana flaccida. This condition is observed in the feeble-minded with other cranial defects in development. Moos and Steinbrügge observed in a cretin, with defective cranial development, a difference of 40° in the inferior angle of the membrana tympani, on each side. In such cases the difference may be from 10° to 50° greater than normal.

The Handle of the Malleus.—Running from above downward and backward to the centre, or umbo, of the tympanic membrane is seen the ridge formed by the *manubrium* or handle of the hammer. This slightly elevated ridge, entirely opaque and decidedly whiter than the surrounding membrana tympani, is in the diameter which divides the tympanic membrane into two unequal parts, the anterior being the smaller and the posterior the larger. At the upper end of this ridge is the short process of the malleus, projecting sharply outward, somewhat above the general surface of the handle of the hammer. In general appearance it is not unlike a pimple with pale-yellowish contents. The lower end, or tip of the ridge, which curves slightly forward, is flatter, broader, and yellower than the rest of the outer covering of the manubrium. This is due to the fact that the bone at this point is spade-shaped, and also because the radial fibres of the middle layer, the *membrana propria*, centre at this lower end of the handle. The lower end of the hammer draws the membrana tympani very markedly inward, and forms the depressed centre of the membrane called the *umbo.* The concavo-convex shape of the drumhead from the tip of the manubrium outward toward the periphery is due to the comparatively large number of circular fibres at a point between the umbo and periphery, which constrict, as it were, the radial fibres so as to form a kind of funnel.

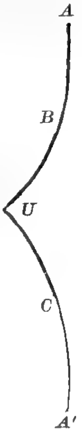

FIG. 1680.

Pressure or traction applied to the centre of a membrane stretched over a ring tends to draw the former into a conical shape, a vertical section of which is represented by the line *AUA'* in Fig. 1679. But if a smaller concentric ring be placed at *BC*, in Fig. 1680, so as to resist the indrawing force at *U*, the curve assumed by the membrane will be represented by the line *AUA* in Fig. 1680, and the whole membrane will be drawn into a concavo-convex surface, the line *AUA'*, Fig. 1680, representing on the right-hand side the curve of the tympanic membrane on its outer surface.

The yellow spot at the end of the handle of the malleus, in the centre of the umbo, is a purely physiological condition. It is, in fact, part of the cartilaginous structure at the end of the manubrium of the hammer.

Trautmann[1] concluded that: 1. Its physiological significance is the same as that of an epiphysis of a long bone. 2. The diagnostic value of the yellow spot is apparent in cases of thickening of the membrana tympani, as the former will disappear much sooner than the sharp edge of the malleus. 3. Opacities of the membrane with thickening change the color of the yellow spot. 4. When the malleus is twisted on its long axis the form of the spot will be altered. 5. If the spot does not move during alterations in the atmospheric pressure in the canal induced by the pneumatic speculum, it is fair to conclude that either ankylosis of the malleus or its adhesion to the inner wall of the drum cavity has occurred. In the latter instance, the differential diagnosis is aided by the necessary foreshortening of the handle of the hammer.

Folds of the Membrana Tympani.—From the short process of the manubrium of the malleus two delicate ridges may be seen, one passing forward, the other backward to the periphery. These are the so-called folds of the membrana tympani. They are formed by the pressure outward of the short process of the malleus, and constitute important topographical as well as diagnostic points in the tympanic membrane. Above these folds is the so-called membrane of Shrapnell, or the membrana flaccida. It owes its flaccidity to the small quantity of fibrous tissue entering into its composition, and to the loosely stretched cutaneous and mucous layers of the membrana tympani which here come together. In the upper part of this flaccid membrane there was once *said* to be a normal opening, the *foramen Rivini*, named after the supposed discoverer in 1717. Its existence finally was denied by Hyrtl, and his conclusions are now universally accepted.

Pyramid of Light.—The pyramid of light is the name applied to the beautiful triangular reflection of light emanating from the antero-inferior quadrant of the normal adult membrana tympani. The apex of this triangular reflection touches the tip of the manubrium of the malleus, and its base lies on, or near, the periphery of the membrana tympani. It forms, with the handle of the hammer, an obtuse angle anteriorly, that becomes greater as the inclination of the membrana tympani to the auditory canal diminishes. Its average height is from 1.5 to 2 mm., and its average width at the base is from 1.5 to 2 mm. The causes of the formation of this pyramid of light, or its optics, have been variously described by a number of careful observers. From the most recent investigations,[2] it is conclusively shown that there are three elements indispensable to the formation of the pyramid of light—viz., a shining surface, the peculiar inclinations of the tympanic membrane, and its peculiar funnel or convolvulus-like shape. In these three conditions may be found the solution of three very important questions, viz.: 1. Why do we see such, or any reflection from the tympanic membrane? 2. Why do we see this one in the antero-inferior quadrant? and, 3. Why is its shape pyramidal?

1. We see a reflection because of the lustrous epithelium on the dermoid layer of the membrane. 2. The peculiar inclination of the tympanic membrane so places the latter that, by the modifications of its surface brought about by the traction inward at the umbo, or centre, the only possible spot from which light can be reflected is just where the pyramid of light is seen, as will be explained further on. 3. The funnel shape of the membrana tympani will explain the pyramidal shape of this reflection upon the physical laws of concavo-convex mirrors.

Not one of these conditions is sufficient of itself to produce a normal pyramid of light upon the tympanic membrane. That the lustre of the skin layer is an important factor in producing this peculiar reflection may be proved by syringing an ear in which this pyramid of light is visible. After a slight maceration and consequent dulling of the lustre of the outer surface of the membrana, the pyramid of light will have disappeared or become distorted.

In order to prove that the peculiar inclinations of the membrana tympani toward the walls of the auditory canal have also their part in the production of the pyramid of light at the point where it is normally found, *i.e.*, in the antero-inferior quadrant, it is necessary only to inspect a normal tympanic membrane during inflation by the Valsalvan or any other method. It will then be seen that the pyramid of light becomes altered in position respecting the malleus.

That this reflection can come only from the antero-inferior quadrant is shown by an experiment of Politzer, as follows: If the auditory canal be removed from the membrana tympani, so that the latter is attached only to the annulus tympanicus, and the membrane then be revolved so that other parts of its surface successively assume the position of that from which the pyramidal reflection formerly came, we shall perceive on each of these parts a reflection almost exactly like the original pyramid of light, excepting behind the manubrium, where, owing to the different curve of the membrane, the reflection in question will be somewhat different, both in shape and brilliancy.

The third important condition in the formation of the pyramid of light is the funnel shape of the membrana tympani, to which is due, according to Trautmann, the pyramidal shape of the reflection under consideration.

The cause of the pyramidal shape of the "reflection of light" from the membrana may be thus stated: The normal tympanic membrane has quite a high degree of lustre, is inclined at an angle of 45° in its vertical plane, and in its horizontal plane it is inclined 10° toward the right on the right side and 10° toward the left on the left side. Furthermore, it is drawn inward so as to form a concavo-convex funnel (page 583), the apex of which lies in the centre of the anterior part of the yellow spot at the lower end of the handle of the malleus. The angle at which the sides of this funnel meet is greater than a right angle, the depth of the funnel is equal to about 2 mm., and the distance from the apex to the periphery is from 2.5 to 3 mm. anteriorly and 3 mm. posteriorly. But a reflection of light from the surface of the membrana tympani, were it flat, could not reach the eye of an observer, because the rays of light from without, on account of the inclination of the membrana tympani, would fall upon the plane surfaces of the same at a very acute angle, and since the angle of reflection is equal to the angle of incidence, the rays of light reflected from the planes of the membrane, having an angle of 45°, would strike the inferior wall of the external auditory meatus, and in consequence would be unable to reach the eye of an observer from without. The relations, however, are different in a reflection from a concavo-convex tract. For, on account of the vertical inclination of 45° in the membrana tympani, and of its horizontal inclination of 10°, and also because of its concavo-convex shape, the antero-inferior quadrant of the tympanic membrane is drawn at right angles to the illuminating point. Since, now, the illuminating body and the eye are in the same line in examining the ear, only the rays of light which fall perpendicularly upon the antero-inferior quadrant can reach the eye, since all other rays are reflected at such an angle that they strike the walls of the auditory canal; therefore, the only reflection of light seen by the observer comes from the antero-inferior quarter of the tympanic membrane, and constitutes the "pyramid of light."[3]

Geometric Divisions of the Tympanic Membrane.—It has been suggested[4] to divide the membrana tympani into two grand tracts, the one above, the other below the folds of the drumhead (*ae*, *ed*, Fig. 1681). The upper tract is subdivided into three sectors: viz., *aeb*, *bec*, and *ced*, Fig. 1681. The sectors are bounded below by the folds of the membrana tympani, and above by the annulus tympanicus and the segment of Rivinus, *bc*. The middle sector, *bec*, is separated from the other two on each side by the two suspensory ligaments *be*, *ec*, of the handle of the hammer. Between the anterior suspensory ligament *be* and the anterior fold of the membrana tympani lies the anterior sector, and between the posterior suspensory ligament and the posterior fold of the membrana lies the posterior sector. The inferior division of the membrana tympani, viz., that portion below the folds, is divided into an anterior segment, beginning at the anterior fold and extending to the pyramid of light, and the posterior segment, extending from the pyramid of light to the posterior fold of the membrana.

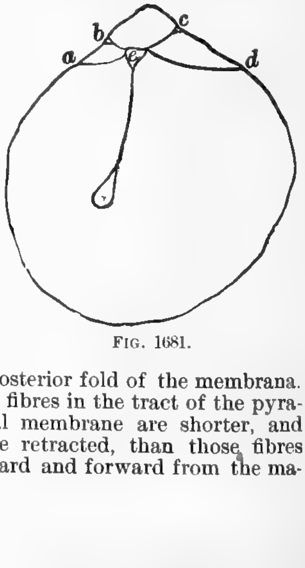

FIG. 1681.

It is said that the radial fibres in the tract of the pyramid of light of a normal membrane are shorter, and therefore tenser and more retracted, than those fibres which run directly backward and forward from the manubrium.

The Tendinous Ring (*Annulus Tendinosus*).—Before considering the membrana propria, the structure from which the fibres of this middle layer of the tympanic membrane originate, demands a short description. This is the so-called tendinous ring of Arnold. It is a mass of fibrous tissue around the periphery of the membrana tympani, effecting the union between the latter and the inner edge of the external auditory canal. This tendinous ring is wanting at the segment of Rivinus (upper pole of the membrane). It is, furthermore, not always visible from without, even when present in its normal position around the periphery, close to the annulus tympanicus.

The fibres of the membrana propria, the origin of which has just been explained, are not inserted directly into the bone of the manubrium, but into a cartilaginous groove which receives the manubrium and short process.[5] It presents in general the appearance of a deep groove, when seen from behind, after the removal of the malleus. Gruber has shown that this groove is closed at its upper end, so that it forms a cartilaginous cap, which covers in the short process on all sides; its lower end, on the contrary, is open behind, and it gradually becomes shallower or flatter, until lost in the substance of the membrana tympani. It extends from a little above the short process to a point half a millimetre below the spade-like end of the manubrium. The inner surface of this cartilaginous groove, which is in contact with the malleus, is lined by a very delicate layer of connective tissue, between which and the malleus there is found a small quantity of fluid resembling synovia. If this is so, there is here a kind of joint. Now and then cases are observed presenting, as it were, *two* short processes. Such an appearance is explainable as a result of a luxation upward of the malleus out of this cartilaginous groove. The upper one of the two is the true short process, in such instances. Kölliker[6] regards this hyaline cartilage as a remnant of fœtal life. He does not admit the presence of a normally developed, constant space between this cartilage and the malleus.

Membrana Propria: the Middle, Fibrous Layer of the Tympanic Membrane.—This layer may be subdivided into two distinct and very delicate layers, an *outer* one, composed entirely of radiate fibres, closely connected with the skin layer of the membrana, and an *inner* layer, composed entirely of circular fibres, in close relation with the mucous membrane composing the inner layer of the tympanic membrane. These are called the radial and circular layers of the membrana propria. The fibres of the first arise from the *annulus tendinosus* and the upper wall of the auditory canal, and are inserted into the handle of the hammer, centering for the most part at the umbo. The fibres composing the circular layer arise partly from the *annulus tendinosus*, but the majority arise from the substance of the membrana tympani itself (von Troeltsch). Some of them are inserted into the malleus. The circular fibres are most numerous a short distance from the periphery of the tympanic membrane. They are thickest in the upper third of the membrane, where they are twice as numerous as the radial fibres. The thickness of the circular layer at this point is 0.026‴, while that of the radial layer is 0.018‴ (Gerlach).

The circular fibres are much less numerous at the middle third of the space between the malleus and periphery, and almost wanting at the centre of the membrana. A knowledge of the arrangement of these fibres is important when considering pathological changes which may have taken place in the tympanic membrane, and also in explanation of its peculiar concavo-convex shape. For, "if its radial fibres were not united by transverse ones, they would be stretched in a straight line. In point of fact, however, they maintain a curved shape, with the convexity toward the meatus. Hence we conclude, that the radial fibres are drawn toward one another by circular fibres, and that the latter are also made tense at the same time. There is, in fact, in the membrana tympani at rest, no other force competent to hold the radial fibres in a curved position, but the tension of the circular fibres."[7] In addition to the two layers of the membrana propria, just described, there is still another layer composed of descending fibres (Gruber). They are external to the radial fibres, arise from the upper segment of the annulus tendinosus, and lying very close to one another, are inserted into the sides and median line of the cartilaginous groove of the malleus. The three layers of fibres entering into the composition of the membrana propria are lightly bound together by a very delicate connective tissue, but they cling very closely to the *annulus tendinosus*, cartilaginous groove, and the dermoid and mucous layers.

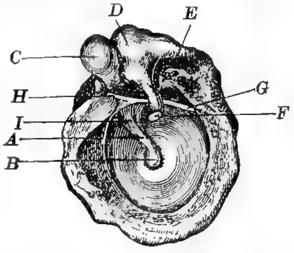

FIG. 1682.—View of Inner Surface of Membrana Tympani. (Gruber.) *A*, Manubrium of the malleus; *B*, the lower end of the manubrium; *C*, head of the malleus; *D*, body of the incus; *E*, short process of the incus; *F*, processus lenticularis of the incus; *G H*, chorda tympani; *I*, insertion of the tensor tympani muscle.

There is also in the membrana tympani a set of fibres arranged in a peculiar way, and first described and named by Gruber — the *dendritic* (*arborescent*) *fibrous* structure of the tympanic membrane. "They arise near the periphery, about in the middle of the posterior segment, pretty far apart, but as they proceed on their upward course in the posterior segment, they approach one another in order to divide again, at some distance from the manubrium of the malleus, into several branches, usually about three, which run in different directions, and are finally lost by intertwining with the fibres of the membrana propria."[8] These fibres are not confined to the posterior segment, but traces of them are found throughout the membrana tympani. The function of these fibres is considered by Gruber to be, in all probability, to relax the tympanic membrane, although it cannot be shown as yet that it is muscular. The membrana propria consists chiefly of connective tissue of that variety, half-way between the ordinary fibrillated and the homogeneous connective tissue of Reichert, as shown by Gerlach. The fibres are 0.004‴ broad, and 0.002‴ thick. Upon these ribbon-like fibres are found peculiar spindle-shaped corpuscles, once supposed to be peculiar to the membrana tympani, and named the "corpuscles of the membrana tympani," or the "corpuscles of von Troeltsch," after the observer who first called attention to them. They are, however, only the connective-tissue corpuscles of Virchow. They are 0.002‴ long, and about 0.005‴ wide at their broadest part, with two or three processes. They are found under two forms, the spindle shape and the stellate (Gruber).

Internal or Mucous Layer of the Tympanic Membrane.—The internal layer of the membrana tympani is of mucous membrane, a continuation of that lining the tympanic cavity. It is thickest at the periphery of the tympanic membrane, growing thinner as it approaches the centre of the membrana tympani, where it is extremely delicate. On the inner surface of the layer various investigators have found villous bodies (Politzer, Gerlach, Kessel). They resemble intestinal villi in appearance, and are usually found in delicate children. They are globular or finger-shaped, the former being from 0.10‴ to 0.12‴ in diameter, and from 0.12‴ to 0.14‴ in length. The finger-shaped villi vary in length from 0.10‴ to 0.12‴, and in width from 0.06‴ to 0.08‴ (Gerlach and Gruber). As no nerves have ever been found in these bodies, and as they are connected to the mucous membrane by means of pedicles, they should be regarded as villi rather than as papillæ (Gerlach). They are never found below the upper third of the malleus, nor are ever more numerous than eight. The finger-shaped ones are 0.02 mm. long by 0.05 mm. in breadth, according to Moos,[9] who asserts that they are prolongations or protrusions of the mucous membrane, covered by a single layer of ciliated cylinder epithelium, and contain one vascular loop. It is not yet decided whether they are constant in the fœtus and new-born child or not.

Fold of Mucous Membrane Enclosing the Chorda Tympani.—Near the upper boundary of the tympanic membrane the mucous membrane of its inner surface is reflected over the chorda tympani, and back again to the drum-head. This duplicature is visible in some cases from without, as a grayish line, both in front of and behind the malleus. This fold or duplicature, being adherent to the neck of the malleus, is thus divided into an anterior and posterior portion, and aids in the formation of the so-called pouches of the tympanic membrane (von Troeltsch) which will be described later.

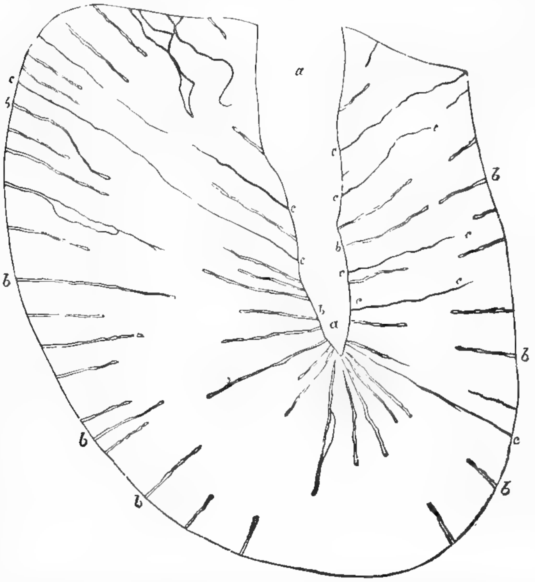

FIG. 1683.—Membrana Tympani of Dog. (C. H. Burnett.) This woodcut is from a drawing of a chloride of gold preparation made by the writer. *a*, *a*, Vacancy left by the handle of the hammer, or malleus; *b*, *b*, *b*, *b*, vascular loops; *c*, *c*, ordinary capillaries, not looped.

Blood-Vessels of the Membrana Tympani.—The tympanic membrane is supplied by the tympanic branch of the inferior maxillary artery, and also by a short direct branch from the internal carotid artery, in the carotid canal. By the latter channel the membrana tympani may become engorged very quickly.

There is in the tympanic membrane of the dog, the cat, the goat, and the rabbit, a series of *vascular loops* running from the periphery of the membrane toward the malleus. A similar series of loops runs both posteriorly and anteriorly from the malleus toward the periphery of the membrane (Fig. 1683).

There is also a distribution of blood-vessels in the tympanic membrane of the guinea-pig peculiar to it. It is arranged in the form of a net, with coarse quadrangular or hectagonal mesh. In man the vascular mesh is similar to that of the guinea-pig, but much closer and with coarser vessels.

The Ossicles of Hearing.—In the tympanic cavity of mammals there are *three* small bones: The *malleus*, or hammer; the *incus*, or anvil; and the *stapes*, or stirrup. Anatomists of a later day have shown that the once so-called *os orbiculare*, or *os Sylvii*, does not exist as a separate bone; but that which once received this name is the *processus lenticularis* of the long process of the *incus*, which fits into a corresponding depression in the head of the *stapes*.

The *malleus*, or hammer, received its name from Vesalius, and is divided into a head, a neck, and a handle. At the junction of the handle with the neck are two important processes, viz., the short process on its outer aspect, and the process of Rau or Folius, which passes anteriorly into the Glaserian fissure. In the fœtus and the new-born child this process is about three and a half lines long, and can be removed with the malleus. After birth it unites with the under wall of the Glaserian fissure, and when the malleus is removed only a short piece of the former long process is found attached to it. This remnant attached to the malleus was all that was known of the former long bony process to the older anatomists, among whom was Folius, from whom this process has received the name of *processus Folianus* (Venice, 1645).

In its entirety it has been called the *processus Ravii*, after Rau or Ravius, who described it to his pupils. It has also been called the *processus longus seu spinosus*. It is united to the Glaserian fissure, in adults only, by a mass of ligamentous tissue, which permits slight motion in any direction. The *head* and *neck* of the malleus project into the tympanic cavity, and are entirely free from the tympanic membrane. The rounded smooth head is directed anteriorly, and the surface which articulates with the incus is directed backward. The long diameter of its articular surface runs vertically; the short diameter horizontally. In the direction of the former the articulating surface has been said to resemble a saddle, for the surface is divided a little below the middle by a horizontal ridge, and depressed on each side of it. This articulating surface is also concave in its short diameter, *i.e.*, from without inward. If a shallow oval basin, the long diameter of which is considerably greater than its short diameter, be placed across a ridge and then bent downward, and at the same time slightly twisted on itself, the cavity thus formed will fairly represent the articulating surface of the malleus. The neck of the malleus connects the *head* with the *manubrium*, or handle. It makes, with the head, an angle of about 135°, opening inward toward the drum cavity. There are three distinct surfaces on the neck of the hammer: a broad *inner* one turned toward the tympanic cavity, bounded in front by the process of Rau, or the long process of the malleus, and behind by the long, low, bony elevation for the insertion of the tendon of the tensor tympani muscle; an *anterior* surface, lying above the ridge running from the short process to the long process, and extending to the angle made by the head of the malleus with the neck, and separated from the posterior surface by a sigmoid ridge for the insertion of the *ligamentum mallei externum* of Helmholtz; and a *posterior* surface, which lies between the aforesaid sigmoid ridge in front, the edge of the articulating surface of the malleus above, the low, long process behind, and a line drawn from the insertion of the tensor tympani to the short process below. Of all the surfaces of the neck the posterior one glides most gradually into the *manubrium*.

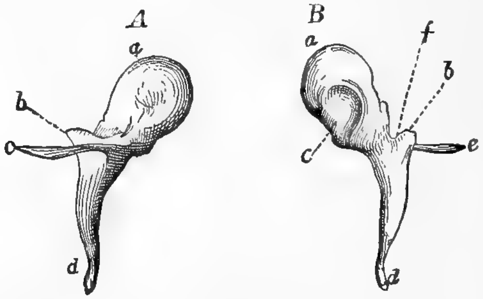

FIG. 1684.—Malleus of the Right Side. *A*, From in front; *B*, from behind. (Magnified four diameters. Henle.) *a*, Head; *b*, short process; *c*, long process; *d*, manubrium; *e*, articular surface for the incus; *f*, the neck.

The handle or *manubrium* of the malleus, that part of the ossicle inserted into the tympanic membrane, also has three surfaces, which may, in fact, be considered prolongations downward of those of the neck. Since all these surfaces gradually approach one another, and are united in the tip or point of the manubrium, the latter may be said to resemble a three-sided bayonet, one ridge of which passes from the short process directly downward to the tip, and consequently is turned toward the external auditory canal. The lower end or tip of the handle of the malleus is flattened into a small disc, one surface of which is turned toward the auditory canal. This spot is plainly visible as the pale, round centre of the *umbo*.

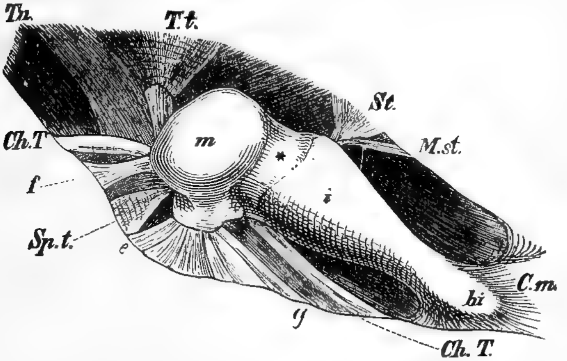

FIG. 1685. — Ligamentous Support of Ossicles seen from above. (Helmholtz.) *e*, *g*, Attachment of the ligamentum mallei externum; *m*, head of malleus; *i*, body of incus; *hi*, posterior attachment of incus; *Tu*, entrance to Eustachian tube from the tympanum; *St.*, stapes; *M.st.*, stapedius muscle; *T.t.*, tendon of stapedius muscle leaving the cochleariform process; *Ch.T.*, *Ch.T.*, chorda tympani, marking the free edge of the fold of mucous membrane, bounding the pouches; *f*, the upper tendinous fibres of the ligamentum mallei anterius, originating above the spina tympanica major, *Sp.t.*; *, malleo-incudal joint.

The long axis of the handle of the hammer is convex posteriorly and inward, so that when viewed from without the manubrium appears concave on its anterior and outer surfaces. This is especially marked at the lower third on the anterior surface, so that the manubrium appears curved decidedly forward near its lower end. Along the ridge of the manubrium, directed toward the external auditory canal, several small, node-like prominences are sometimes observed. These are purely physiological; but their origin is obscure.

The *dimensions* of the malleus are as follows: It is nearly 9 mm. long, its manubrium being from 4 mm. to 5 mm. in length, and its head 2.5 mm. thick. The latter is the greatest diameter of any part of the bone The long diameter of the articulating surface of the malleus is about 3 mm.; the short diameter is between 1.5 mm. and 2 mm. In twenty cases examined by Urbantschitsch only five were found in which the *malleus* was equal in length on both sides. The malleus is held in position by four ligaments, viz.: the *ligamentum mallei anterius*, *ligamentum mallei superius*, *ligamentum mallei externum*, and the *ligamentum mallei posterius*. The *ligamentum mallei anterius* is a broad band of fibres, holding the *processus Folianus* against the *spina tympanica major*. This ligament may be said to arise from the *spina tympanica major* and to be inserted along the neck of the *malleus* all the way from the *processus Folianus* to the head of the hammer. A portion of it also runs from the *processus Folianus* to the short process of the hammer below, and to the *membrana tympani* above, thereby aiding the division between the anterior and posterior pockets of the *membrana tympani;* another fold of the same ligament runs from the *processus Folianus* downward, with a free margin, as far as the line corresponding to the insertion of the *tensor tympani* muscle. This aids in making the limiting wall between the anterior pocket of the drumhead and the tympanic cavity. The round *ligamentum mallei superius* descends obliquely downward and outward from the *tegmen tympani* to the head of the hammer. Its function is to prevent the malleus from being forced outward.

The *ligamentum mallei externum* is a very important collection of satin-like, tendinous fibres, which radiate from the sigmoid crest on the front of the neck of the hammer, and are inserted into the sharp edge of the segment of Rivinus on the temporal bone. It prevents the hammer from being forced inward, and, being inserted above the axis of rotation of the hammer, it prevents the *manubrium*, which is below the axis of rotation, from moving too far outward toward the auditory canal.

The *ligamentum mallei posticum* is really the posterior edge of the ligament just described as the external ligament of the *malleus*. As the line followed by this bundle of fibres passes through the *spina tympanica major*, and since it represents very closely the axis of rotation of the hammer, Helmholtz has suggested that it should be considered a separate ligament, and he has given to it the name it bears. As this ligament and the *ligamentum anterius* are, in a mechanical sense, one ligament, although the hammer comes between them, the two sets of fibres have been named the axis ligament of the hammer (Helmholtz). The plane of the axis ligament is not quite horizontal, being a little higher in front than behind. In all its motions as a lever (pendulum-like) the *malleus* swings about this axis as the fixed point. All portions of the bonelet above its short process are above this axis ligament, and all below the short process are below this axis, or fulcrum-line. The *ligamentum mallei anterius* of Arnold was once described as a muscle, and called the *laxator tympani major* (Soemmering). It is, however, only a ligament which originates from the *spina angularis* of the sphenoid, passes through the petro-tympanic fissure (Glaserian fissure), and is inserted into the *malleus*. Under the name of *ligamentum mallei posticum seu manubrii*, the *ligamentum mallei externum* of Arnold, Lincke describes a ligament which passes from the upper edge of the end of the external auditory canal to the short process of the *malleus*, and occupies the position of a supposed muscle, once called the *M. laxator tympani minor*, or *M. mallei exterior seu Casserii*. It is now universally acknowledged that muscular fibres do not exist here (Henle).

The Incus or Anvil.—The middle one of the three auditory ossicles is the incus or anvil. The name is derived from the shape of its upper half. This small bone is divided into a body and two processes, viz., a long and a short one. The latter is also called the horizontal process. It is held to the posterior and to the upper walls of the tympanic cavity by ligaments. This is an important point in the mechanism of the ossicles. The longer process is also called the descending ramus of the *incus* (see Fig. 1686). It curves gradually outward and downward, assuming a slight sigmoid shape; at its tip or lower end it curves rather sharply inward, to unite with the head of the *stapes* by means of the *processus lenticularis*. The narrowest part of the incus is at the middle of the body of the bone. Beneath this part it widens out again anteriorly into the important part which locks with the malleus in all its inward movements, and posteriorly into the descending ramus or long process. The articulation between the *malleus* and *incus* is a true joint, in which is found a *meniscus* (Rüdinger). If this articulation is viewed on its outer surface, *i.e.*, on that side which

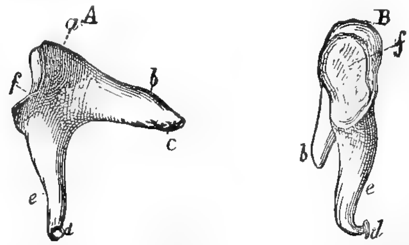

FIG. 1686.—Right Incus. (Magnified four diameters. Henle.) *A*, Inner surface; *B*, view in front; *Aa*, and *B*, body; *b*, short process; *e*, long process; *d*, processus lenticularis; *f*, articular surface for the head of the malleus; *c*, surface which lies in contact with wall of tympanic cavity.

is toward the external auditory canal, it would seem that the *incus* quite overlaps or embraces the head of the hammer. When viewed, however, from the tympanic side, it appears that the largest share in the joint belongs to the *malleus.* This is due to the peculiar structure of this joint, first pointed out and explained by Helmholtz in 1869 ("Mechanik der Gehörknöchelchen," etc.). The greatest length of the *incus* is in a vertical line passing from the top of the body of the bone through the long process. It measures 7 mm. The horizontal upper edge of the body measures 5 mm. Its greatest thickness, 2–2.5 mm., is at its articulating surface for the *malleus.*

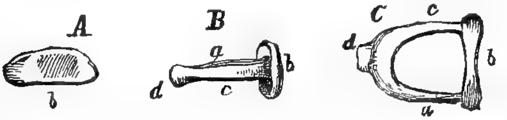

FIG. 1687.—Right Stapes. (Magnified four diameters. Henle.) *A*, From within; *B*, from in front; *C*, from beneath; *b*, foot plate or base; *d*, capitulum; *c*, anterior; *a*, posterior shaft or crus of stapes.

Malleo-Incudal Joint.—Helmholtz has graphically described this joint as follows: "It is, in fact, like the joint used in certain watch keys, in which the handle cannot be turned in one direction without carrying the steel shell with it, while in the opposite direction it meets with only slight resistance. As in the watch key, so here, this joint, between the hammer and anvil, admits of a slight rotation about an axis drawn transversely through the head of the hammer toward the end of the short process of the anvil; a pair of cogs oppose the rotation of the manubrium inward, but it can be driven outward without carrying the anvil with it." It is of that kind of joint known as ginglymus. The mechanism of this joint is best understood when it is known that the malleus is a lever, the fulcrum of which passes just below the short process. This, of course, leaves the head and neck—*i.e.*, the articulating surfaces for the malleo-incudal joint, and all the free tympanic parts of the malleus—above the line of support of the lever, the handle or manubrium being below.

The latter is the long arm of the lever, and consequently all its movements are repeated in an opposite direction on the head of the malleus. Each inward movement of the handle, therefore, causes a slight outward motion of the head of the hammer, and a firm locking of the malleo-incudal joint, by which the *incus* is carried about an axis drawn transversely through the head of the hammer toward the end of the horizontal or short process of the anvil. The *incus*, or anvil, being also suspended as a lever, about the line just named, when all above that line moves outward, all below the line moves inward, *i.e.*, as the upper part of the *incus* is moved outward the long process swings inward and carries the *stapes* ahead of it, thus forcing the foot plate of the latter into the oval window.

The Stapes, or Stirrup.—The smallest bone in the body, and the innermost one of the three auditory ossicles, is the *stapes*, or stirrup. Its name is derived from the striking resemblance it bears to a stirrup (Fig. 1687). It is divided into a head, a neck, two branches or legs (*crura*), and a foot plate or basis. The head, which is like a cup-shaped button, is placed at the junction of the two *crura.* It is designed for the reception of the lenticular process of the *incus*, with which it forms a ball-and-socket joint. There is a meniscus in this joint, according to Rüdinger. On the posterior surface of the head of the stapes the stapedius muscle is inserted. The two legs, or *crura*, are furrowed on their inner surface, which makes them stronger than if they were flat. The legs of the stapes arise from the base or foot plate, forming a graceful arch, and unite above in the head as stated above. The foot plate, or *basis* of the stapes, is nearly oval (slightly kidney-shaped), thicker at the periphery than in the centre, slightly convex toward the vestibule, and concave on its tympanic surface; it fits into the oval window, where it is held by a fibrous packing. This permits a slight inward and outward motion on the part of the stapes. When this ossicle is in position, the long axis of its base is horizontal and coincides with that of the oval window. In this position the convex edge of the base looks upward, and its concave edge, which gives it to a slight degree the shape of a kidney, looks downward. The *ligamentum obturatorium stapedis* is a thin membrane stretching across the space between the base and the legs; it is attached to the crista of the former and the furrow on the inner edges of the latter. The *stapes* (stirrup) measures nearly 4 mm. from its head to the under surface of its base. The latter is 2.5 mm. long in its horizontal diameter, 1 mm. in its vertical diameter (the bone, of course, must be imagined in normal position), and about ½ mm. thick at its edges. It is slightly concave toward its centre.

The Joint between the Base of the Stirrup and the Oval Window.—According to Helmholtz ("Mechanik der Gehörknöchelchen") the base of the stapes is surrounded at its edge by a band of fibro-elastic cartilage 0.7 mm. thick. Over the inner surface of the base of the stapes, which is directed toward the cavity of the vestibule, in the plane of its outer wall, extends the periosteum of the wall of the vestibule, but the fibrous band on the edge of the foot plate, which fits into the oval window, is not attached to the latter, which leaves the stapes free to move slightly in and out of this fenestra. The mucous membrane of the tympanic cavity extends over the outer or tympanic surface of the base of the stapes. Regarding the fixation of the base of the stirrup in the oval window, the conclusions of A. H. Buck (1869) are as follows: 1. The base of the stapes is fastened to the edge of the oval window by means of a ligament of elastic fibres. 2. These fibres gradually converge toward the edge of the foot plate of the stapes. 3. The ligament arises from the periosteum in the neighborhood of the oval window and passes over to the base of the stirrup, when it again assumes the function of periosteum. 4. The breadth of the ligament is the same all around the periphery of the base of the stapes.

The Malleo-Incudal and Incudo-Tympanic Joints.—The malleo-incudal and incudo-stapedial joints may be regarded as a variety of symphysis or synchondrosis.[10] These connections, furthermore, are not to be regarded as true or ordinary joints. They are all of peculiar structure, since between the cartilaginous surfaces of the bones there is a fibrous, or a fibro-cartilaginous, intermediate substance. Rüdinger reasserts the true joint-like structure of the articulations of the ossicula.[11] He also maintains that in both the malleo-incudal and incudo-stapedial joints there is a fibro-cartilaginous disc connected with the capsular ligament, but not with the hyaline covering of the articular surfaces of the bones.

If the *tegmen tympani* be removed, let us say, from the *right* tympanic cavity, the malleo-incudal joint and the incudo-tympanic joint will be exposed to view (see Fig. 1688), and just in front of the head of the *malleus*, but below it, will be seen the tendon of the *tensor tympani* muscle coming upward and inward from the left, to be inserted into the tubercle on the neck of the hammer. Above this tendon, winding from within outward, and to the right (in the figure) around the neck of the malleus, is seen the

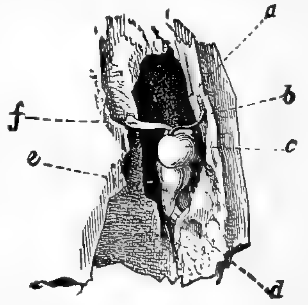

FIG. 1688.—Right Tympanic Cavity viewed from above; Malleo-incudal and Incudo-tympanic Joints. (Magnified two diameters. Henle.) *c*, Head of malleus; *e*, short process of incus; *f*, tendon of tensor tympani muscle; *d*, capsule of incudo-tympanic joint; *a*, ligamentum mallei anterius; *b*, chorda tympani nerve.

chorda tympani on its way to the Glaserian fissure. The suspensory ligament of the malleus is attached to the under surface of the roof of the tympanic cavity, but is not shown in the figure, as it has been removed with the *tegmen*.

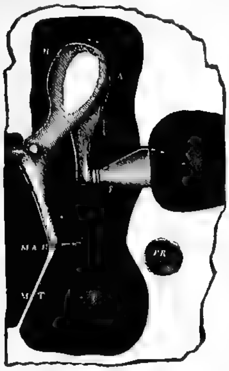

FIG. 1689.—Diagrammatic Representation of the Relation of the Ossicles to One Another, to the Membrana Tympani, and to the Internal Ear. (Buck.) *T*, Cavity of tympanum; *L*, labyrinth; *M.A.E.*, meatus auditorius externus; *H*, hammer; *A*, anvil; *S*, stirrup; *M.T.*, membrana tympani; *F.R.*, fenestra rotunda.

Dimensions of the Ossicula.—Urbantschitsch, by comparing the *ossicula auditûs* of fifty different tympana, found that the *malleus* varied in length from 7 mm. to 9.2 mm., the average length being 8.5 mm. The short process varies from 1.2 mm. to 2.6 mm., with an average length of 1.6 mm. The long process (the Folian) was found in one case, an individual thirty years of age, to be 2.5 mm. long, and in another, a man twenty years of age, 5.8 mm. long. The *manubrium* has an average length of 5 mm. from the short process above to the end below. In the *incus* the distance of the upper end of the articular surface from the free end of the horizontal ramus is, on the average, 5.3 mm. The under end of the surface of the joint is 4.6 mm. distant from the incudo-stapedial joint.. The incus is the most porous of the ossicles. The average length of the *stapes* is 3.7 mm.; its average breadth between the crura, 2.3 mm. Its head is either entirely straight (twenty-nine times) or inclined toward the anterior (eighteen times) or posterior limb (three times); in one case the head pointed upward, *i.e.*, toward the upper edge of the foot plate of the *stapes*.[12]

The Weight of the Ossicula Auditûs.—The weight of the auditory ossicles varies greatly with the age of the individual. It is also a fact that the proportionate weight of the ossicula, one to another, is not constant. In the new-born child the proportionate weight of the *malleus* to the *incus* is generally as twenty to seventeen, and in a malleus weighing 20 mgm. the weight would be distributed as follows: The head of the *malleus*, including that portion of the neck just above the short process, 16 mgm.; the long process, including the short process, 4 mgm. In an incus weighing 17 mgm. the body of the incus, including the short process and the base of the *processus longus* as far downward as the lower lip of the inferior articulating surfaces, weighs 14 mgm.; and the long process with the *processus lenticularis* attached, 3 mgm., the corresponding *stapes* weighing very nearly 4 mgm. In the adult the weights of the *malleus* and the *incus* are, as a rule, more nearly equal; in some cases, however, the proportionate weight of the *malleus* to the *incus* is as seven to eight.[13] According to the same observer, the distribution of the weight of the ossicula, above and below the axis line (see page 587), is as follows: In a *malleus* which weighed 21 mgm. and an incus 25 mgm., the combined weight of the portions of these two bones, above the axis line, was 30 mgm.; that below the line, 16 mgm., or in the proportion of fifteen to eight. This preponderance of weight in the parts of the *malleus* and *incus* above the axis line tends to act as a mechanical counterbalance, and renders the two bones better able to swing upon the axis line. It also serves to increase the delicacy of a mechanism which responds to sound waves in excursions so infinitesimal that the highest powers of the microscope cannot detect them (Helmholtz).

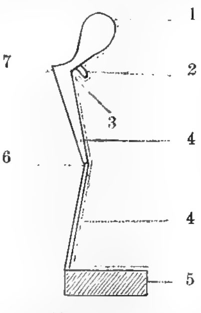

FIG. 1690.—Diagrammatic Representation of the Formation of the so-called Pouches of the Membrana Tympani. (C. H. Burnett.) 1, Mucous membrane of the inner surface of the membrana tympani, as shown by dotted line; 2, reflection of same over the chorda tympani; 3, pouch of the membrana tympani; 4, 4, inner surface of the membrana tympani; 5, section through osseous floor of the tympanic cavity; 6, umbo of the membrana tympani; 7, short process of malleus.

The three ossicles which have been described, when joined together, form the so-called chain of auditory bonelets. They then act as sound conductors between the membrana tympani, in the external ear, and the vestibule, in the internal ear (see Fig. 1689). Every inward movement of the tympanic membrane is followed by a similar inward motion of the stapes, and the foot plate of the latter impresses the lymph in the labyrinth and, mediately, the terminal filaments of the auditory nerve in the cochlea and other parts of the internal ear. The compression of the lymph in the labyrinth finds a compensatory yielding at the membrane of the round window. Were this not so, the nerve filaments would be in danger of too much compression with each sound wave which carries the chain of ossicles inward.

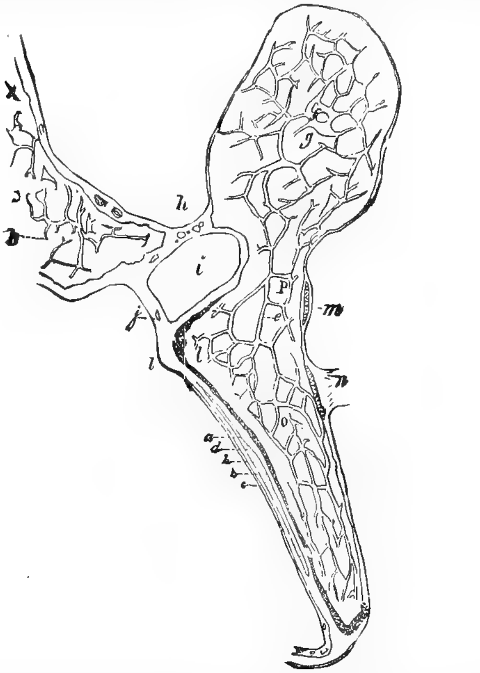

FIG. 1691.—Section through the Long Axis of the Malleus at Right Angles to the membrana Tympani. From an adult. (Brunner.) Bony edge of the so-called scute or inner edge of upper wall of auditory canal, in the segment of Rivinus; *g*, head of the malleus; *p*, neck of the malleus; *o*, handle of the malleus; *l*, short process of same; *j*, membrana flaccida; *h*, ligamentum mallei externum; *m*, chorda tympani; *n*, tendon of tensor tympani; *i*, a cavity, according to Prussak and others; *a*, cartilage; *b*, *b*, fibres of the membrana tympani; *c*, dermoid layer of the membrana tympani; *e*, Haversian canals; *f*, medullary space.

The membrana tympani forms most of the outer wall of the tympanic cavity. The limit of this outer wall is made by the annulus tympanicus. Upon the inner surface of this outer wall of the tympanic cavity lie the manubrium of the malleus, the chorda tympani, and the duplicature of mucous membrane about the latter, which forms also the so-called pockets of the tympanic membrane.

These pockets or pouches of the membrana tympani are the spaces lying between the upper edge of the membrana tympani and the aforesaid duplicature of mucous membrane around the chorda tympani nerve, in the so-called horizontal portion of its passage through the tympanic cavity. There are two, the anterior or smaller one and the posterior or larger pocket, formed in the following manner (see Fig. 1690, 1, 2, and 3). After the mucous membrane of the tegmen tympani has been reflected over the chorda tympani, it ascends again to reach the upper edge of the drum membrane, in order to form the inner or mucous layer of the tympanic membrane; therefore the chorda tympani nerve is found at the free edge of a fold of mucous membrane which, with the membrana tympani, forms a groove opening downward (Fig. 1690, 3). Since the chorda tympani clings to the inner surface of the neck of the malleus, this groove or pocket is divided into two compartments, named as already mentioned. They were first described by von Troeltsch in 1856. He asserted that the *posterior* one contained in its structure traces of the fibrous layer of the tympanic membrane, but this is denied by Gruber and Bochdaleck. The *posterior* pouch is about 3 mm. high and 4 mm. broad. This pouch is best seen when the tympanic membrane is viewed from within, but it can also be seen from without when the tympanic membrane is thin and well illuminated.

The *anterior* pouch lies in front of the malleus, and is much smaller than the posterior pouch. Its inner wall is composed of mucous membrane only. It contains "all the elements which proceed from or enter the Glaserian fissure."

There is a *third* or *middle* pouch of the tympanic membrane described by Prussak and Gustav Brunner (Fig. 1691, *i*). This cavity is bounded behind by the neck of the hammer, below by the upper surface of the short process of the malleus, in front by the membrana flaccida, and above by a ligamentous band, the *ligamentum mallei externum*, which is inserted between the *margo tympanica* and the *spina mallei*. This cavity is separated from the anterior tympanic pouch by the upper blind end of the latter abutting on the neck of the hammer; posteriorly, it communicates with the tympanic cavity by a good-sized opening, above the position of the posterior tympanic pouch. This pouch, being thus placed in communication with the tympanum, may become filled with mucus or pus, and consequently ruptured.

Charles H. Burnett.

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[1] Archiv f. Ohrenheilkunde, Bd. xi., pp. 99–113.

[2] Trautmann: Archiv f. Ohrenheilkunde, Bd. viii., 1873.

[3] Trautmann: *Loc. cit.*, p. 28.

[4] Kessel: Archiv f. Ohrenheilkunde, Bd. viii., 1874.

[5] Gruber: Studien über das Trommelfell, Wien, 1867.

[6] Gewebelehre, p. 707.

[7] Helmholtz: Mechanism of Ossicles of the Ear and the Membrana Tympani.

[8] Gruber: *Op. cit.*, p. 35.

[9] Archives of Otology, 1885, p. 46.

[10] Gustav Brunner: Monatsschr. für Ohrenheilk., No. 1, 1872.

[11] Monatsschrift f. Ohrenheilkunde, No. 3, 1872.

[12] Archiv für Ohrenheilkunde, Bd. xi., 1876.

[13] Dr. C. J. Blake: Transactions American Otological Society, vol. i., p. 543.

EAR DISEASES: ACUTE CATARRHAL OR NON-SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR.

—General Considerations.—In the beginning of an acute inflammation of the middle ear, and not infrequently for a considerable length of time after the apparent onset of the attack, it is impossible to determine whether the case should be classified as one of a suppurative or as one of a non-suppurative character. It is only after the acme of the disease has been reached, and after it has been ascertained what is the character of the inflammatory product that is poured out into the tympanic cavity, that we are warranted in classifying the particular case under observation as belonging to the one or the other category. If the inflammatory product is composed merely of serum, intermingled or not, as the case may be, with a few blood and lymphoid corpuscles, it is generally customary to speak of such an attack as an acute catarrhal or non-suppurative inflammation of the middle ear. But if the product under consideration quickly assumes a purulent character, and especially if the membrana tympani gives way and allows it to flow out into the external auditory canal for a period of one or more days, it is proper to designate such a case as one of acute suppurative inflammation of the middle ear. It is difficult to resist the belief that in both of these types or varieties of middle-ear inflammation the underlying cause is an infection; some milder forms of bacteria serving as the exciting factors in the non-suppurative variety, while in the other variety the more virulent micro-organisms must be held responsible for the suppuration and for the actual destruction of tissue

An acute catarrhal inflammation of the middle ear is a very common affection in the northern and middle zones. A large proportion of the cases designated by the laity as cases of "earache" will be found to belong in this category of acute catarrhal inflammations of the middle ear

Etiology.—Undue exposure to cold while the body is in a heated condition, and especially to a draught of cold air, is by far the commonest cause of an acute catarrhal inflammation of the middle ear. Ducking and diving under water (especially salt water) is also occasionally a cause of such an attack, although in the majority of instances the result is a suppurative rather than a non-suppurative form of inflammation. Water may also enter the tympanum in the treatment of the nasal cavities by means of the nasal douche or the posterior nares syringe, or even when water is drawn into the nostrils by the patient himself. Finally, the disease may develop as a consequence or accompaniment of certain infectious diseases such as scarlet fever, measles, smallpox, whooping-cough, and cerebro-spinal meningitis.

Symptoms.—*Pain.*—Adults suddenly find themselves seized with an agonizing pain in one, rarely in both, ears. If they are of an observing turn of mind, they will recall the fact, when they are thus seized with pain, that the throat felt sore and thickened for a few hours before the attack began. This, however, is not always the case. The pain is usually sudden in origin and goes on increasing in intensity until the rupture of a distended veinlet in the vicinity of Shrapnell's membrane, or of an epidermal sac containing blood-stained serum, or perhaps even of the membrana tympani itself, puts an end to the tension of the sensitive parts.

A Sense of Fulness in the Ear.—A marked sense of fulness or of stuffiness in the ear is another very annoying subjective symptom of this disease. It is likely to last as long as there is any appreciable swelling of the walls of the Eustachian tube.

Tinnitus Aurium.—This symptom, common to affections of the tympanum, is often a violent one in acute inflammation. In the first stages it is usually of a puffing or blowing character.

Resonance of One's Own Voice.—This symptom, sometimes termed *autophony*, is to many patients very annoying. It disappears with the subsidence of the swelling of the inflamed tympanic mucous membrane.

Impairment of the Hearing.—The extent to which the hearing is affected varies greatly in the different cases, and bears no fixed relationship to the degree of hyperæmia and infiltration manifested by the visible portions of the membrana tympani. In most cases the hearing is not sufficiently impaired—even when both ears are involved—to exclude the patient from the pleasures of ordinary conversation. Now and then, however, the degree of impairment is very marked, and in these particular cases it is difficult to resist the belief that the labyrinthine cavities and structures are more or less involved in the inflammation.

Constitutional Disturbance.—In adults there is usually no rise in the body temperature and very little if any acceleration of the pulse rate; but in young children there may be well-marked feverishness, with a temperature reaching as high as 103° or even 104° F. In some cases the child may manifest an unnatural drowsiness, but in others the opposite mental state—that of excitableness and fretfulness—will be observed.

Appearances Presented by the Membrana Tympani.—The picture presented by the drum membrane varies according to the stage which the disease has reached at the time when the examination is made. If the membrane is seen at an early period of the attack, before pain has become the prominent symptom, the peripheral portions, especially the upper, and the region of the manubrium mallei will show evidences of congestion and beginning infiltration (Fig. 24, Plate xxv.). Farther along in the attack it may be found that the epidermis, in the vicinity of Shrapnell's membrane, has been pushed outward in the form of a bleb by exuded serum or even by pure blood that has escaped from a ruptured blood-vessel. In other cases the exudation remains confined chiefly to the tympanic cavity; in which event bulging of the drum membrane—more noticeably of its posterior half—will be the most conspicuous alteration. Finally, if the examination is made at a time when a watery, perhaps blood-stained, fluid is escaping from the orifice of the external auditory canal, it will be seen that all the usual landmarks have disappeared and that at the farther (inner) end of the canal nothing but a soaked epidermal surface, of very irregular form, can be distinguished.

Differential Diagnosis.—There are only two other pathological processes which might perhaps be mistaken for the disease which is now under consideration. These are an acute eczematous inflammation of the inner half of the external auditory canal, involving the dermoid aspect of the membrana tympani, and an acute suppurative inflammation of the middle ear. So far as the eczema is concerned, the previous history of the case, the absence or the insignificance of the pain, the small degree of the impairment of the hearing, the probable absence of tinnitus, and the marked hyperæmia and infiltration of the skin covering the inner half of the external auditory canal,—all these facts will warrant us in assuming that we are dealing with this malady and not with an acute inflammation of middle-ear origin. On the other hand, no degree of familiarity with the pathological pictures presented by the membrana tympani and no degree of care in studying the other data furnished by the case in hand will enable the expert otologist to predict, with any degree of certainty, whether the disease will eventually prove to belong to the non-suppurative variety or whether it will assume the more serious characteristics of an acute suppurative inflammation. Fortunately, it is not a matter of any great practical importance that he should be able, at this comparatively early stage of the inflammation, to differentiate between the two. In either event he would employ the same plan of treatment; a change being called for only when it becomes clear that he is dealing with a disease the essential nature of which is an invasion of infective micro-organisms.

Prognosis.—The prognosis in this disease is almost unqualifiedly favorable. The middle ear, after the subsidence of the acute attack, returns slowly to a condition of health, and it is only in a few exceptional cases that some slight permanent impairment of the hearing remains after the attack has entirely subsided.

Treatment.—An acute inflammation of the tympanum usually requires active treatment, especially in adults. The practitioner should at once combat the striking symptom, that is, the pain. The first means to be tried is the hot douche. Water of the temperature of from 100° to 105° F. should be allowed to run into the ear, from a fountain syringe or the like. The stream of water should be continuous; hence, the piston syringe is of no use under these conditions. This instrument is only valuable as a means of cleaning the ear, or of removing a foreign body. In case the warm douche fails to give relief in a few minutes, and if the patient is not an infant or a very young child, from one to four or even six leeches should be applied upon the tragus, according to the severity of the symptoms and the age of the patient. In addition to this the patient should usually be confined to his room, and be in bed, while the general indications of the disease, the condition of the bowels, the skin and the pharynx, are met by appropriate treatment. Usually the leeches will soon subdue the pain, and appropriate hygiene, without drugs, will allow the case to go on to recovery. It will sometimes be necessary to repeat the leeching and to continue the use of the douche for some days; opium may also be required, but opium without local blood-letting will be of little or no service. Some authorities speak well of the instillation of a solution of sulphate of atropine, gr. ij. ad ℥ i., and of hydrochlorate of cocaine in a four-per-cent. solution, instead of the warm douche, but these remedies will not avail, except in mild cases. Hot vapors are sometimes of service. An old remedy is a poultice applied in the canal. The "heart" of a hot onion is especially used. Such a poultice will quiet the pain in many cases, but since it favors suppuration, and may lead to suppuration of the drumhead, its use is not generally proper.

Inasmuch as the question of paracentesis of the membrana tympani will be discussed by the writer of the article on the suppurative form of acute inflammation of the middle ear, it will not be necessary for me to say anything on this subject.

As soon as the acute symptoms have subsided it will be found advantageous to practise Politzer's method of inflation daily, and to wash the pharynx freely with a saturated aqueous solution of warm chlorate of potassium, Vichy, or the like. This treatment should be persisted in until the hearing power becomes normal, as tested by the watch, tuning-fork, and the human voice.

D. B. St. John Roosa.

EAR DISEASES: ACUTE SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR.—Among the numerous diseases to which humanity is liable there is probably no single one which is capable of causing so much suffering for a short time, or is more dangerous to life, than an acute suppurative inflammation of the middle ear; to say nothing of the liability of the disease to cause the impairment if not the destruction of the function of one of the most important organs of special sense, on which are largely dependent the giving of knowledge to the individual, his social position in life, and his general well-being. Yet until within a very few years this disease has been treated as though it were a necessity in every household, a condition through which every child should pass; and even at the present time this way of looking at the disease prevails to some extent.

The distinction between an acute catarrhal inflammation of the middle ear and an acute suppurative inflammation is not always well marked in the early stages of the disease; the suppurative form being doubtless in many instances the outcome of the catarrhal, in consequence of infection or of some other unfavorable circumstance.

Acute suppurative otitis media constitutes from five to ten per cent. of all ear diseases, according to the character of the climate in which the patient resides; being more prevalent in one which is characterized by frequent, rapid, and extreme changes in temperature, and by the prevalence, to a greater or less degree, of dampness. Then, again, the disease is of more frequent occurrence among the poor, among whom the hygienic conditions are especially unfavorable.

The onset of the disease is usually sudden and is attended by violent febrile symptoms lasting for from a few hours to several days; the remission of the most severe symptoms generally occurs soon after the rupture of the drumhead, an occurrence which liberates the pent-up purulent exudate. The discovery of this discharge in the auditory canal is often the first indication of ear disease and even the first circumstance which leads the physician to think of the existence of any trouble in that organ.

The anatomy of the upper portion of the tympanic cavity, known as the epitympanic recess, is especially favorable for the development of suppurative inflammation. Enclosed within this little dome are the bodies of the two larger ossicles, the malleus and incus, and the ligamentous bands which hold these in position—reduplications of mucous membrane and connective tissue. Frequently this network of tissue is so developed as to divide the tympanum into two distinct parts. Opening into this upper part of the tympanum posteriorly are the aditus, mastoid antrum, and mastoid cells. In the anterior wall of the lower or main portion, at about its centre or a little below, is the orifice of the Eustachian tube, and on the medial wall are the two fenestræ of the labyrinth—the fenestra rotunda, closed by a membrane, and the fenestra ovalis, closed by a membrane on which rests the foot plate of the stapes. Two important nerves are liable to be involved in an inflammatory process in the middle ear—the facial and the chorda tympani. The facial courses along the posterior and medial wall, usually being enclosed in its bony canal; sometimes, however, it is covered only by mucous membrane, thus exposing it to any inflammation that may be present. The chorda tympani runs free, arching over the middle portion of the cavity from behind forward, near the upper margin of the membrana tympani. Involvement of the latter in an inflammatory process would be of comparatively little moment, while inflammation of the facial might be a more serious matter. The anastomoses between the vessels of the tympanum and those of the labyrinth afford a means whereby exudation may take place within the labyrinth, injuring the hearing and sometimes giving rise to inflammation and suppurating disease in these parts. And then again the intimate relationship between the tympanic cavity and the membranes of the brain must be borne in mind; the paths of communication between the two being often so numerous as to afford the most favorable conditions for pyogenic infection of the structures within the cranial cavity. In children it is not uncommon to find, as a result of the incomplete ossification of the petro-squamosal suture, an opening of considerable size in the roof of the tympanic cavity, in consequence of which the dura mater is in contact with the mucous membrane lining the tympanum or may even dip down into this cavity. In such cases an acute inflammation of the middle ear would encounter but little resistance in spreading to the intracranial tissues and might there cause more or less serious disturbance.

Bacteriology.—Research has been made by a number of careful observers, both in this country and abroad, in this interesting and important department of medicine, for the purpose of determining, if possible, the specific micro-organisms, or particular combination of organisms, which produce this form of tympanic inflammation; but, so far as can be determined with any degree of accuracy, no special microbe or constant combination of microbes is to be held responsible for this disease. It was at one time considered that the streptococcus was the most constant etiological factor in the serious and fatal cases of ear disease, but recent statistics have shown that the staphylococcus was present in about as many fatal cases as the streptococcus. During the past four years, at the Rhode Island Hospital, the pus examined has shown, in the milder forms of inflammation, a great variety of organisms, various combinations, and some which could not be classified. In the more severe cases, in which septic intoxication was pronounced, pure cultures of staphylococcus were found in the majority of cases; the streptococcus being present, however, in a larger number of the cases in which the mastoid was involved. In comparing the two principal kinds of infection, the staphylococcus and the streptococcus, from a symptomatic standpoint, it was found that in the cases in which the Staphylococcus pyogenes aureus was present in pure cultures, the symptoms were more acute, and the bodily temperature was higher; the pain in the region of the ear was more intense and continued longer after perforation of the drumhead had been established either spontaneously or by artificial means; the discharge of pus was more profuse, the pus itself being more acrid, as manifested by excoriations of the tissues of the external ear and, after opening of the mastoid process, by erosions of the skin about the wound and by the frequent sloughing out of the stitches; and, finally, the general course of the disease was more rapid, demanding operation sooner, on account of the extension of the disease into the mastoid cells. On the other hand, an invasion by staphylococci seemed to be less often accompanied by swelling and redness of the mastoid integuments than was the case when the infection was due to the streptococcus. In a carefully prepared report of one hundred and one cases by Dr. J. Orne Green the examinations show the great variety of micro-organisms which are present in this disease. These statistics show practically the same variety and classification as had previously been shown by most of the careful and experienced observers. Dr. Green's principal object in his report was to show the character of the original infection of the tympanum before an opening of the drumhead had exposed the cavity to secondary infection. After making the canal as nearly aseptic as possible the drumhead was incised and the artificial culture was made from the first drop of pus. In seventy-three out of the one hundred and one cases pure cultures were reported as follows:

Staphylococcus (albus, 8; aureus, 9; variety not stated, 19)	36
Streptococcus	19
Pneumococcus	10
Bacillus diphtheriæ	2
Bacillus pyocyaneus	3
A capsule bacillus	3

Leaving 28 cases of mixed infection, or 28 per cent.

Flesch and Haug found gonococcus.

Pathology.—From the anatomical make-up of the epitympanic recess we can readily understand what a perfect incubator for micro-organisms this space must make when in a state of inflammation. With the large surface of mucous membrane—which, as has been said, "if spread out would be as large as a silver quarter,"—enclosed within a cavity no larger than a dried pea, we can imagine that when hyperæmia and infiltration of the mucous membrane take place, as must happen in acute inflammation, considerable pressure must result and, in consequence, the circulation and nourishment of the parts must be greatly interfered with. This, together with the pressure of the surfaces of the folds of mucous membrane upon each other, results in necrosis of the epithelial surfaces and even—as the disease progresses—of the subepithelial tissues. As soon as swelling begins there is thrown off an exudation consisting of pus cells, mixed later with blood and mucus, in which are found the bacteria previously spoken of. The purulent exudate is formed over the whole surface of the mucous membrane, extending into the orifice of the Eustachian tube and into the mastoid antrum and cells. It is often diffused into the tissue substance itself, and small abscesses have been found between the mucous membrane and the surface of the bone. When the inflammation takes place in the presence of scarlet fever the infection seems intensely virulent and tissue necrosis takes place very rapidly. This is especially noticeable in the rapid perforation of the drumhead. In some cases the necrosis extends to the ossicles and to the walls of the tympanum quite early in the disease. As was stated in an earlier paragraph, the epitympanic recess is sometimes quite cut off from the lower part of the tympanum. When this happens the swollen mucous membrane is forced outward above the short process of the malleus, pushing out Shrapnell's membrane, or the posterior upper portion of the membrana propria. Sometimes, before perforation takes place, the protrusion of the mucous membrane pushes this flaccid portion outward to such an extent that it will hang down over the membrana propria, obscuring it more or less and being often mistaken for a polypus. But it is quite unlike a polypus, as will be seen if care is used in the examination, and, furthermore, if incised, it will discharge pus. In some cases in which this point of bulging is incised, there will take place, after the lapse of a few days, a prolapse of the mucous membrane. This last condition is even more apt than that described above to be mistaken for a polyp. If this nipple-like projection continues for a number of days after incision and after proper treatment has been carried out, the case must be closely watched for other indications of mastoid involvement, as this is one of the important symptoms of that complication. Sometimes, instead of forming this polyp-shaped mass, the pus dissects its way between the membranous portion of the canal and the bone, and forms an abscess. In children it is quite common for this dissection of pus to continue along the posterior wall of the canal, between the bone and the periosteum, and to find its way out upon the outer surface of the mastoid process, where it forms a post-auricular abscess. In these cases it has been the experience of most surgeons, who have looked for it, to find pus in the mastoid cells. The pus, after reaching the post-auricular region, frequently finds its way into the glandular and cellular tissues of the neck. The most common course of the disease, however, is to extend downward from the epitympanic space, in the direction of least resistance, into the lower part of the tympanum, involving the tissues in this region, and causing marked bulging of the drumhead proper, with swelling, inflammation, and œdema of its tissues. In these cases the perforation is more frequently located in the posterior half of the drumhead, about half-way between the tip of the manubrium and the posterior margin, or a trifle higher up, near the incudo-stapedial articulation. Early in this form of the inflammation the Eustachian tube becomes closed by swelling of its lining mucous membrane. Doubtless in many cases, if the tube could be kept open, the more serious complications of the disease might be avoided.

ETIOLOGY.—The causes of this disease are many and varied. The primary causes may be divided into two general classes: *External*, including traumatic and climatic; *Internal*, including inflammatory and circulatory. The secondary cause, in both classes, is pyogenic infection.

Among the external traumatic causes are the *direct*—as by operative procedures on the drumhead or in the middle ear; by violence to the parts, *e.g.*, by forcible removal of foreign bodies; by forcible syringing; by a direct stab wound of the drumhead; by boxing the ear; by greatly increased pressure upon the drumhead—*e.g.*, by compressed air, as in tunnelling and mining, in diving, and in concussion of the air by an explosion or by the firing of a cannon; and, finally, by scalding, by local irritants, by caustics, etc. Among the *indirect* causes are contusion of the skull, as from a blow or a fall.

Climatic causes are exposure to cold and wet, or allowing the wind to blow for a long while in the ear. Then there are causes which are external to the middle ear, as for example, an extension of inflammatory conditions of the external auditory canal to the tissues of the drumhead, and from thence to its mucous coat, and ultimately to the entire lining membrane of the middle ear. Among these inflammatory conditions are. external otitis, both diffuse and circumscribed, eczema, hardened and impacted cerumen, and foreign bodies which have been embedded in the canal for a long time. I recall a case of a Russian who applied to me for relief from an earache. I removed from his canal a piece of lead pencil three-fourths of an inch long. When he saw it he remembered having hidden it in his ear eight years before while in the Russian army. Dr. Buck reports cases of gouty inflammations of the canal which extended to the middle ear. There is still another cause which is often placed in this category. I refer to the development of an inflammation in the middle ear from the entrance of cold water into the external auditory canal during sea bathing. In some cases this is doubtless the correct explanation of the otitis media, but, in a larger number, it is more probable that the cold water is forced into the tympanum from the naso-pharynx, during the act of blowing the nose. In a similar way solutions of salt and water and other solutions used for cleansing and for medication of the mucous membrane of the nose and naso-pharynx, in catarrhal conditions or after operations, may be forced into the middle ear. In like manner secretions of pus, or muco-pus, coming from the nasal accessory sinus, or the discharge which is present in "head colds," may be driven into the tube and tympanic cavity, if the patient is in the habit of blowing the nose violently. Inflammation of the middle ear has occasionally occurred after nasal operations—such as straightening the nasal septum or the removal of spurs and ridges—and also from cauterization of the turbinated bodies. Now and then such an inflammation follows the operation for the removal of adenoids.

According to the published reports, there have been cases in which foreign bodies have found their way through the Eustachian tube, from the naso-pharynx, into the middle ear I had a case in which a spear of grass, over an inch long, worked its way through the tube from the throat and set up an acute inflammation of the middle ear which continued for several months. Finally, while mopping out the ear, I discovered this dark-pointed object lying in the tympanum, and grasping it with the forceps, I pulled out through the perforation in the drum membrane what proved to be a piece of grass. Almost immediately afterward the suppuration ceased and the perforation healed.

Internal Causes of Inflammation.—In this list influenza or la grippe has been responsible for probably a larger number of cases of suppurative inflammation of the middle ear and its complications than can be attributed to any other one disease. Among the other causes may be mentioned nearly all of the exanthematous diseases, especially scarlet fever and measles. Then come "cold in the head," or acute naso-pharyngeal catarrh, diphtheria, smallpox, typhus and typhoid fevers, whooping-cough, syphilis, erysipelas, tuberculosis, diabetes, etc. In children hyperplasia of the lymphoid tissue in the naso-pharynx—or "adenoids," as they are commonly termed—is probably the most common predisposing cause. When these hypertrophied glands are present the slightest exposure to cold and wet is liable to precipitate an attack of inflammation of the middle ear; and if scarlet fever, measles, or diphtheria should supervene the chances of escaping serious trouble would be greatly lessened.

Circulatory Conditions.—There is yet some mystery regarding these conditions, but we know that in cases of pneumonia there occasionally occurs an acute suppurative inflammation of the middle ear, usually on the same side as the affected lung. There is no direct extension, so far as can be seen, but it is evident that the disturbance in the circulation of the lung does in some way influence the circulation in the middle ear, and as a result engorgement and inflammation take place. One or two cases of this nature may appropriately be cited here. A hack driver, who while in good health had been exposed to severe weather, was seized, a few hours later, with a violent pain in the ear. On examination it was found that the tympanic blood-vessels were gorged with blood and that the middle ear was filled with serum; and in the course of a few hours it became plain that a suppurative inflammation was under full headway in this tympanum. Another instance is that of a young child, who while teething was suddenly taken with earache; and this pain proved, after the lapse of a few hours, to be due to the development of a suppurative inflammation in the middle ear.

In some of these cases the inflammation may be attributed to reflex influences, while in others it seems more plausible to attribute it to a suspension of vaso-motor inhibition. But however this may be, there can be no doubt that some disturbance of the circulation lies at the bottom of these attacks of acute suppurative inflammation of the middle ear; and, if we seek for the cause of such circulatory disturbances, we shall doubtless often be able to find it in some other organ, as, for example, the lungs, the liver, the kidneys, the teeth, and the nervous system.

Dr. Downie gives the following statistics of 501 cases of tympanic involvement treated in the Children's Hospital in Glasgow:

	Cases.	Per cent.
Originated during measles	131	26.1
" " scarlet fever	63	12.6
" " whooping-cough	15	3.0
" " mumps	3	0.6
" " simple catarrh	147	29.4
" " dentition	101	20.0
Syphilitic	8	1.6
Doubtful	33	6.7

SYMPTOMS.—The onset of the disease is usually signalized by severe pain and high fever, both of these symptoms being influenced by the age of the patient, and by the former conditions of the tissues of the region affected.

Pain.—In infants there is little evidence of pain, as the drum-head is very thin and ruptures very easily; and, besides, the disease, at the stage of rupture, is more often of the catarrhal type, infection taking place later through improper care and imperfect cleansing. In fever patients and in tuberculous patients there is often little or no pain. Pain, however, is pre-eminently the most important symptom. It is localized deep in the ear, and is sharp, lancinating, throbbing in character, radiating from the depths of the ear forward to the temple or over the parietal region or backward over the mastoid and occipital regions. It also frequently extends down the sides and back of the neck or into the teeth, to the pharynx, or even to the larynx. It may remain confined to either one of these locations, or it may involve several at one time. Often pain in the temple of the affected side persists for days after the earache has been relieved. In other cases the pain in the head is more noticeable than that in the ear, and the real cause of it may be discovered only when attention is called to a discharge from the external auditory canal. In most cases the pain in the ear is excruciating and, on account of the accompanying pain in the head, becomes alarming to the patient. We have no standard for measuring pain, but, as affording at least some measure for comparison, I may mention the fact that women of experience have told me that they suffered greater pain from the earache of this disease than from the act of childbirth. Possibly in adults the pain is more prolonged than it is in childhood on account of the greater resistance of the tissues of the drumhead to spontaneous rupture. The pain, furthermore, is usually more severe during the evening hours or during the night. Relief generally follows perforation of the drumhead, whether it occurs spontaneously or as a result of surgical interference; but it is more immediate and more complete if afforded by early incision. In cases in which the disease has progressed for several days before the pent-up pus has been liberated, and in which the inflammation has become established in the mastoid antrum and cells, only partial relief follows the opening of the drumhead. In this class of cases the paroxysms of pain are more liable to occur between midnight and three o'clock in the morning. Experience has taught me to attach considerable value to this fact as an indication of mastoid complication; and when the pain recurs at about one or two o'clock in the night, for several nights in succession, even though the patient may be comparatively free from pain during the remainder of the twenty-four hours, I feel that the case is almost sure sooner or later to come to operation, and the earlier the mastoid is opened, in a case of this character, the better for the safety and comfort of the patient. Blowing the nose, sneezing, coughing, bodily exertion, stooping over, and mental excitement increase the pain.

Fever.—Fever is a very constant symptom. The usual range of temperature is from 100° to 102° F., and in exceptional cases it may go as high as 103° or even 105° F. It is usually higher in children than in adults, and is irregular and intermittent in its course. After perforation of the drumhead takes place, the temperature usually drops, but in some cases it remains elevated for several days. When it is variable in character, with a long range—say from 99° to 103° F. or more, dropping and rising irregularly—systemic infection and sinus involvement are to be feared. While careful observation of the bodily temperature is necessary in cases of feverish illness, yet in this disease it is unreliable as a guide; for the temperature may remain normal or nearly so, and yet serious trouble may be going on in the middle ear and mastoid cells. In many of the worst cases of mastoid inflammation the temperature does not rise above 99° or 100° F.

In children the pain is often so severe and the temperature so high that meningitis is feared, especially when the little sufferer rolls its head about, as it so often does. Rupture of the drumhead, however, usually gives relief at once, and the severe symptoms soon subside.

Tenderness.—There is frequently considerable tenderness about the ear, over the tragus, beneath the lobe, and over the mastoid, close to the auricle. Generally, this soon passes off after a perforation has become established in the drumhead; but if it still persists over the mastoid region for a day or two after perforation has taken place, it is right to infer that there is probably involvement of the mastoid cells.

Subjective Noises.—This symptom occurs next in frequency to pain, is present in nearly all cases, and sometimes causes the patient fully as much discomfort as the pain itself. Subjective noises accompany the inflammatory process from the earliest stages and are due to disturbances of the circulation both in the middle ear and in the labyrinth. They may also be due to the presence of exudate either in the tympanic cavity, where it causes pressure on the fenestræ of the labyrinth, or among the structures of the latter cavity. These noises vary greatly in character and are described by the patient as roaring, hissing, beating, pounding, ringing, etc. They persist and are more noticeable after the pain has ceased, and are very annoying. The metallic ringing sound, like that produced by striking a piece of suspended steel, is characteristic of serious involvement of the labyrinthine structures.

Disturbances of Hearing.—A feeling of fulness in the ear with slight deafness is often one of the first symptoms noticed. The patient's own voice does not sound natural, and he is much annoyed when using the voice in talking and especially in singing. As the swelling of the mucous membrane in the epitympanic recess increases the bodies of the malleus and incus become embedded in the swollen tissue and the vibration of these ossicles, as well as of the membrana tympani, is interfered with and finally prevented altogether. With the further progress of the disease the swollen mucous membrane of the whole tympanum and the pressure of the exudate on the windows of the labyrinth quite effectually block the hearing. If this tension is not relieved early by opening of the drumhead, the pressure exerted on the terminal filaments of the auditory nerve will cause them to become paralyzed, and serious impairment of the function of hearing, of a permanent character, is likely to result. On the other hand, when relief is afforded to this pressure early, the hearing is usually entirely restored.

In cases in which the nipple-like projection already mentioned above develops in the upper posterior quadrant of the drumhead, the hearing is apt to be seriously impaired; and yet it is found that when the persistence of this lesion renders opening of the mastoid process necessary, the hearing becomes quite normal soon after the healing of the wound. Ordinarily the functional disturbance, like the physical, increases up to the point of perforation and then decreases. But, according to Politzer, in those serious scarlatinal and diphtheritic forms which occur most frequently in childhood, and in which the expansion of the auditory nerve is disorganized by a simultaneous exudation in this part of the ear or through immigration of micro-organisms, or in those cases in which the bony capsule of the labyrinth is opened by a process of acute bone caries, or, finally, in cases of syphilitic inflammation of these parts of the ear, the power of perceiving sound will completely disappear.

To determine the exact location of the obstruction, a vibrating tuning-fork (C., 512 v. s.) should be placed on the vertex of the skull. If the obstruction is in the middle ear, the fork will be heard louder on the affected side; but if the lesion is in the labyrinth, the fork will be heard better on the unaffected side.

OBJECTIVE SIGNS.—*Appearances of the Drumhead.*—It is seldom that the physician has an opportunity to examine an ear until the disease is well under way. During the stage of congestion the blood-vessels along the manubrium and those along the upper margin of the drumhead become prominent; and as the inflammation progresses the whole vascular system of the membrane becomes congested, in which condition this membrane presents to the eye the picture of a network of fine red lines, and the latter extend over the adjoining posterior and upper walls of the meatus (Fig. 11, Plate xxv.). In severe cases of inflammation, such as occurs in scarlet fever, measles, and influenza, the drumhead becomes bright, livid, or angry red (Figs. 13 and 14, Plate xxv.). In influenza it is commonly dotted with ecchymotic spots, or sometimes the posterior half of the membrane will be one large blood blister. The most prominent point of bulging varies with the focal point of the infection. If it is in Prussak's space, between the head of the malleus and the outer wall of the recess, the prominent point will be at Shrapnell's membrane. In other cases the bulging will be posterior to it or lower down. After the tympanum has become filled with exudation, the whole drumhead bulges, and, if perforation does not take place, the bulging will be strongly marked, the convex portion sometimes protruding a fourth of an inch or more into the meatus. After perforation has taken place there is sometimes a prolapse of the mucous membrane of the middle ear which will protrude into the meatus, even as far as the concha, as I have seen in two instances. After perforation has taken place, it is necessary, if we wish to see the parts well, to cleanse carefully the meatus and remove all the discharge. The presence of a small perforation—too small to be recognized by inspection under ordinary conditions—may be noted by the pulsation of the fluid that may happen to be lying upon the outer surface of the membrane, or by the presence of air bubbles in the depth of the canal. In some cases, in which the Eustachian tube is sufficiently pervious, if the patient holds his nose between the thumb and finger and blows hard, pus may be seen to exude through the perforation, and frequently also the perforation whistle may be heard under these circumstances.

Constitutional Disturbances.—In very young children the symptoms of ear disease are very obscure. The little patient is restless, fretful, refuses to nurse, cries out in its sleep, and appears to be quite ill. In other cases there are dulness and apathy, and in still others there may be convulsions, chills, nausea, and vomiting. After five or six days the discharge appears in the auditory canal, and it is only when this takes place and when simultaneously the violent symptoms disappear, that the idea suggests itself that all these disturbances were due to acute otitis media.

Professor Politzer urges that in all cases of acute feverish illness in children, accompanied by brain symptoms, one should never omit to make a careful examination of the ear, in order to ascertain the condition of the drumhead and whether the symptoms observed in the case originate in the ear or not; it being possible, by the discovery of such an acute inflammation of the middle ear, to prevent—through the adoption of suitable therapeutic measures—the development of dangerous complications. An important clinical symptom of this disease in children, when they are not capable of localizing the pain, is the fact that they often keep the head turned toward the affected side and place their hand on the diseased ear. Posterior torticollis is also a prominent symptom in children.

In older children the symptoms are more definitely accounted for. They complain of the earache early in the attack, and high fever, delirium, rapid pulse, heavily coated tongue, sordes on the teeth and lips, loss of appetite, and sometimes chills, dizziness, vomiting, and diarrhœa are accompaniments of the disease. In adults the principal general disturbance is in the brain and nervous system, being manifested by excitement, even delirium, and fear of mania, on the part of the patient.

I recall the case of a man, sixty-five years of age, who was a surgical patient in the Rhode Island Hospital, and who, for three weeks after an operation, was delirious during the night, and dull and apathetic during the day. His dementia was attributed to ether, but at the end of three weeks the nurse discovered a discharge of pus from the auditory canal. Upon examination of the ear an advanced suppurative inflammation, with mastoid complication, was found to exist. After a few days an operation was performed on the mastoid, and, as soon as the patient recovered from the effects of the ether, his mind was found to be perfectly clear, and it continued to be so from that time onward. Another interesting feature of this case is to be found in the fact that the time between his other surgical operation and the mastoid operation was a blank to him; and when he recovered from the effects of the ether, after the latter operation, he thought it was the first one.

COURSE OF THE DISEASE.—The course of this disease is largely dependent on the cause, on the virulence of the infection, and on the previous physical condition of the patient. The presence of adenoid hyperplasia in the naso-pharynx, of hypertrophied faucial tonsils, and of purulent inflammation of the nasal accessory sinuses, tends to prolong the trouble. Among the constitutional disturbances which are liable to protract the course of the disease in children are the lymphatic habit, the so-called scrofulous condition, pneumonia, the exanthematous diseases, etc. In adults the same effect is produced by diabetes mellitus, Bright's disease, actual tuberculosis, and a debilitated state of the system from overwork or from some previous illness. In any case it is the general rule for all the symptoms to increase in severity up to the time when perforation of the drumhead occurs, and then, in the most favorable cases, the inflammation slowly subsides. If the disease is left to itself perforation usually occurs in from three to five days, unless the drumhead was previously thickened from catarrhal inflammation or as a result of some other disease; in which case perforation may not take place for several days. I have seen one case in which, at the end of fifteen days, the tissues of the drumhead were found to be like leather when the knife was plunged through them. In children and also in those cases in which the drumhead is thin, perforation takes place as a result of pressure; in other cases, however, the establishment of an opening is due to gradual erosion and ulceration of the inner layers of the membrane. That pressure contributes to the final result in these cases also is scarcely to be denied. In all cases in which the drumhead is tough and resisting, there is danger of erosion of the membranes of the round and oval windows and invasion of the labyrinthine structures and of the brain.

In cases in which perforation takes place spontaneously there is, at the time of the occurrence, a feeling of bursting followed by the appearance of a discharge and by more or less immediate relief. In the most favorable cases, which pursue an uncomplicated course, the disease continues for from two to four weeks, the discharge gradually diminishing after the first week and all the distressing symptoms subsiding; and if there has not been much destruction of tissue at the point of perforation, the drum membrane heals readily and soon resumes its normal condition and appearance. If the perforation is large, sometimes the healing will be complete and at other times a permanent opening will remain. In both cases the return of the parts to an entirely quiet condition may require weeks or even months. The hearing soon returns to a normal condition, oftentimes before the perforation has closed and before the evidences of disease have entirely disappeared.

The swelling in the Eustachian tube slowly subsides, and frequently, when the patient blows the nose, the air whistles out through the perforation in the drumhead, or, if that opening is closed, a sensation like a "snap" is felt in the ear.

SEQUELÆ AND COMPLICATIONS.—If the disease is prolonged in consequence of any of the above-mentioned conditions, caries of the ossicles or walls of the tympanum may result, or a chronic suppurative otitis media may become established and thus constitute a constant menace to the patient's life. Then, besides, there is the liability to impairment of the hearing from adhesions or permanent thickening of the mucous membrane around the ossicles or oval window, about the foot plate of the stapes. Loss of hearing may also result from paralysis of some of the terminal filaments of the auditory nerve from continued pressure and interference with the circulation. Subjective noises may last for months or become permanent. Finally, I should add that facial paralysis is occasionally a complication of an acute purulent inflammation of the middle ear, from extension of the disease into the Fallopian canal and inflammation of the facial nerve. Of the more serious complications of the disease—sinus phlebitis, thrombosis of the sigmoid sinus, extradural abscess, etc. —I do not need to speak, as they will be discussed fully in other articles of this series.

Diagnosis.—It is often impossible to make a differential diagnosis, in the early stages of the disease, between acute catarrhal inflammation, acute myringitis, and acute suppurative inflammation of the middle ear, simply from the appearance of the parts that can be seen. In bullous myringitis, the blister is sometimes mistaken for a bulging of the entire drumhead, when, as a matter of fact, it is only the outer dermoid layer which is pushed outward, the fluid lying between this and the substantia propria. When such a blister-like collection of serous fluid bursts and the contents appear in the canal, it may readily be supposed that this fluid represents a discharge from the middle ear. But myringitis is usually of very short duration and, unless caused by an external otitis, it soon subsides after rupture of the bulla. It is of frequent occurrence in children, and care must be used not to open the tympanum unnecessarily and thus perhaps create a more serious form of disease. In adults myringitis occurs less frequently and is usually caused by a previously existing external otitis or eczema. To differentiate this form of disease from acute catarrhal inflammation is still more difficult, for in children and in patients with atrophic drumheads, perforation may take place in the catarrhal form of inflammation; and then, on the other hand, a perforation does not always take place in the purulent variety, and the disease may go on to mastoid or other serious complication without any perforation occurring. After the suppurative inflammation of the middle ear is further advanced, the swelling of the drumhead in its upper portion, and especially in the region of Shrapnell's membrane, constitutes a distinctive feature. Then when a perforation occurs and gives exit to a discharge which contains chiefly pus, with more or less admixture of blood and stringy mucus, the nature of the disease becomes quite evident.

Bacteriological examination of the discharge, if made daily from the time when it first makes its appearance, is likely to afford valuable assistance in diagnosis and treatment.

A careful consideration of the history, etiology, and subjective symptoms of the case, together with a careful speculum examination, should render the diagnosis a comparatively easy matter, at least in adults. In children, however, it is much more difficult to detect the existence of the disease. Nevertheless, the evidence that pressure on the tragus causes pain, and the character of the picture presented by the drum membrane as seen by aid of the speculum and reflected light, should make the diagnosis plain. Considerable stress has been laid on the diagnostic value of the presence of râles which can be heard by means of the auscultation tube while the patient's middle ear is being inflated by Politzer's method or by the catheter. Aside from the question of its value as an aid to diagnosis, I believe this to be an extremely dangerous experiment, inasmuch as a mild type of inflammation may thereby be converted into a serious one, through the conveyance of infectious material into the tympanum or even into the mastoid cells.

Finally, the difficulty of reaching a correct diagnosis may be enhanced by the simultaneous presence of furuncles and pustular eczema in the external auditory canal. Here again we must depend, for reaching a correct diagnosis, on the aid afforded by the head mirror, the speculum, and a good light.

Mastoid Inflammation and Empyema.—The most frequent complication of acute supperative inflammation of the middle ear is inflammation of the mastoid portion of the temporal bone. As we have learned from the anatomy of this region, there is a direct communication between the epitympanic recess and the mastoid cells, through the antrum, and the mucous membrane passes continuously from one region to the other. Consequently any inflammation that may be present in one cavity may easily extend into the other. Thus, when the mastoid cells become inflamed, we are warranted in assuming that this inflammation was set up either through a direct extension from the tympanum or through some of the pyogenic infective material having been forced into them mechanically, as by the act of inflating the middle ear with the air bag or by the patient's forcibly blowing the nose. As instances of direct extension we may mention those cases in which mastoid disease develops in the course of such diseases as measles, scarlet fever, etc. During the past ten years influenza has been responsible for more cases of mastoid inflammation than all other causes combined. In some cases the mastoid complication follows the middle-ear inflammation directly, the severe pain and other distressing symptoms continuing without any remission. In other cases there is an abatement of the pain and fulness during the daytime; these symptoms recurring again soon after midnight. Then again, in still other cases, there seems to be an intermission of several days between the abatement of the middle-ear inflammation and the manifestation of mastoid involvement. The patient seems to be convalescing, when suddenly the pain returns in the night, the patient is restless, and the symptoms of acute inflammation again appear. If the ear now be examined the nipple-like projection spoken of on a previous page will be seen in the upper posterior portion of the drumhead; the inner end of the canal will appear narrower, with a little flattening out of its posterior upper cutaneous wall near the tympanic margin; the discharge may or may not be more profuse; but if there is empyema of the mastoid cells and the perforation in the drum membrane is large enough for free drainage, there will be a profuse discharge of pus—generally of a creamy character,—sometimes enough completely to fill the canal within a few moments after its removal.

Sometimes the connection between the middle-ear inflammation and that of the mastoid is not so immediate as in the cases just described. The acute stage of the middle-ear disease may entirely subside and the perforation in the drumhead become perfectly healed, and then, weeks or even months afterward, the mastoid inflammation will appear; the only apparent connecting link between the original attack and this later complication being a slight dulness in the hearing and a sense of heaviness in the ear, with occasional headache and neuralgic pains. In a recent case which came under my care, there was a history of influenza and earache in June, 1899, at which time the drum membrane broke, a discharge appeared, and then the ear in due time healed without complication. Afterward, however, the patient had "a miserable-feeling head" and slight deafness, both of which symptoms persisted up to the time when she consulted me, viz., in June, 1900. An examination revealed only the picture of a chronic catarrhal inflammation of the middle ear. Under treatment the ear seemed to improve. In the course of a few weeks, however, swelling occurred behind the ear and there was evidence of fluctuation. An operation revealed the existence of an old mastoid inflammation with the cell structure entirely disorganized, and its place occupied by cheesy pus and pyogenic granulation tissue.

The pain of mastoid inflammation in the acute stage is, in its characteristics, very similar to that of an uncomplicated acute purulent inflammation of the middle ear. In certain cases it is referred particularly to the teeth, while in others the patient complains chiefly of the occiput or of one or the other temple. Pressure with the tip of the thumb over the location of the antrum, over the tip of the mastoid process, or over the opening of the mastoid emissary veins, will increase the pain. There are usually swelling, redness, and œdema over the mastoid, and frequently the auricle is displaced downward and outward by these swollen tissues. In some cases the swelling extends over the whole side of the head, as far as the outer angle of the orbit, to the vertex, or to the occiput. The swollen parts may present the appearance of a phlegmonous inflammation, or the amount of inflammation may be so slight as to cause scarcely any recognizable alteration in their appearance. Sometimes there is no visible external evidence of mastoid disease, although it is rare, even in these cases, for tenderness on pressure to be lacking. If the outer cortex of the bone has become perforated by the necrotic process, the pus will escape beneath the periosteum and may burrow beneath the scalp or into the cellular tissues of the neck, causing swelling and induration in the upper part of the cervical region. Professor Bezold, of Munich, was the first to describe a class of cases in which perforation occurred on the medial side of the tip of the process; the pus in these cases burrowing down beneath the sterno cleido-mastoid muscle. A characteristic, in this type of the disease, is the frequent absence of any swelling over the mastoid itself; or if there is any swelling it is very slight in amount. On the other hand, just below the tip, near the insertion of the muscles, there is likely to be some swelling, and this may extend downward nearly to the clavicle. In children acute mastoid disease frequently follows in the wake of scarlet fever, or in connection with a prolonged middle-ear inflammation, the outcome of adenoids in the vault of the pharynx or of a lymphatic tendency. The mastoid cells are not developed in early childhood; there being, as a rule, only one cavity continuous with the antrum, and the walls of this cavity being very thin. In consequence of these anatomical conditions perforation of the external bony wall takes place very readily, and there results a post-auricular abscess. Furthermore, as the inner cortex of the bone is correspondingly as thin, the pus is just as liable to break through into the cranium as it is toward the outside.

Prognosis.—When the disease pursues a simple uncomplicated course, and the general constitutional condition and surroundings of the patient are conducive to recovery, the prognosis—when proper care and treatment are employed—may be considered favorable. On the other hand, it is unfavorable in diabetes, tuberculosis, and syphilis, and in cachectic individuals. The outlook should be stated in guarded terms in cases which have originated in influenza, scarlet fever, diphtheria, and measles; and the same cautiousness is called for when adenoids are present at the same time. The removal of the latter will render the prognosis materially more favorable. If unfavorable complications arise, the prognosis, both as to function and as to life, must be modified. In the case of mastoid inflammation the prognosis should be especially guarded, as the danger of systemic infection, pyæmia, thrombosis, phlebitis, and abscess of the sigmoid sinus is greater in mastoid inflammation and suppuration than in simple uncomplicated inflammation of the middle ear.

Treatment.—The treatment naturally falls into two divisions as regards time: (*a*) before perforation; (*b*) after perforation. If the case is seen early, much can be done to cut short the inflammation, but after it has once become established it runs a definite course. We do not always know exactly, within the first twenty-four hours of the disease, whether we are dealing with the acute catarrhal or the acute suppurative form of inflammation; and it does not matter much, as regards treatment, whether we are able to make this distinction or not, for both forms call, at this stage, for the same measures. If the case is seen within the first twenty-four hours from the very onset of the disease, diaphoresis, by means of a dose (adapted to the age of the patient) of pilocarpine, or of Dover's powder, or of a hot lemonade, together with local applications of dry heat, with douching of the ear with water as hot as can be borne, will frequently lessen the severity of the attack. Dry heat may be applied by means of an ordinary rubber hot-water bottle, or a hot salt bag may be made to fit around the ear, the auricle being left free from the pressure of the bag. In the latter case a hot towel or piece of flannel should be placed over the auricle. A bag filled with hot bran or hops is preferred by some. It is not a matter of any special importance which of these various contrivances is selected, so long as enduring heat is secured. The rubber bag shown in the accompanying illustration (Fig. 1692) will be found extremely useful in the treatment of this class of cases, as it can be used with either hot water or ice, as one prefers. Poultices should never be used unless their action can be closely watched, and, in view of the danger of macerating the soft tissues about the ear and of the auricle itself, their long-continued use should be avoided. The parts should be kept as dry as possible, and after douching care should be used in drying the canal with absorbent cotton. The patient must be kept in a room of equable temperature—say about 70° F.—day and night. It is surprising how slight changes in temperature, or a draught of air, can excite the inflammatory condition, influencing it unfavorably. In the case of an adult it is not necessary to keep the patient in bed after the effects of the sweating have subsided. In the case of a child, however, it will be advisable to keep the patient in bed for a few days. During this stage inflation of the middle ear by Politzer's method is recommended by some as a means of relieving the pain. After the first twenty-four hours, however, this procedure is not only of no avail, but it sometimes actually increases the pain, and at the same time may serve as a means of transporting infectious material into the middle ear, and thus may convert a simple inflammation into a purulent one. Analgesics may be used during this stage for the relief of pain, but their use should not be continued, as they will mask important symptoms, and one can never be sure of the course the disease is pursuing while the patient's perceptive powers are thus being blunted by drugs. If

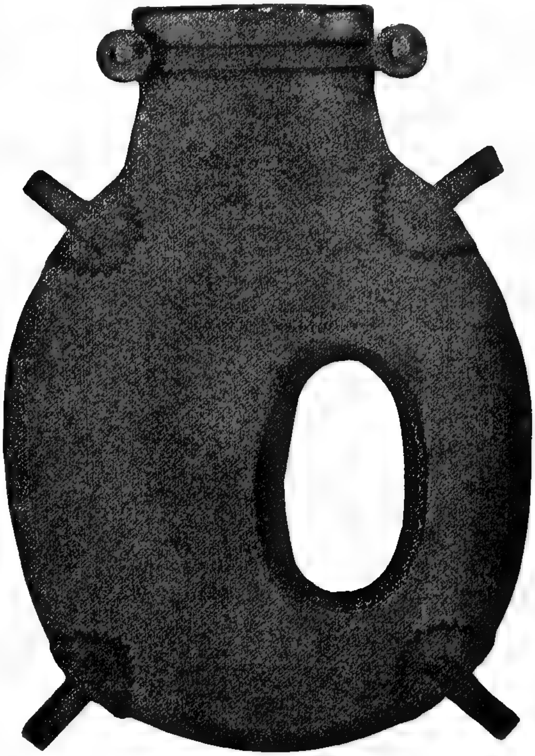


Fig. 1692.—Rubber Bag Devised by Dr. Sprague for Use with Either Hot Water or Cracked Ice in the Treatment of Acute Inflammations of the Middle Ear. (Half natural size.)

the measures already described do not afford relief in the course of a few hours local blood-letting may be resorted to by means of an artificial or a natural leech, to be placed over the tragus or at the opening of the auditory canal. The use of sweet oil and of other greasy substances should never be allowed, as they do no good and may possibly do some harm. Laudanum, atropine, morphine, and cocaine have been highly recommended by some for instillation into the ear for the relief of pain. Recent experiments, however, have shown that a concentrated solution of cocaine, allowed to remain in the canal in such a manner as to cover the drumhead, had no anæsthetic effect whatever on the parts. It is a question whether it is not the heat of the solutions used, rather than the therapeutic value of the drugs which they contain, which affords the relief that is sometimes obtained. If depletion and the means enumerated do not afford prompt relief, and if the drumhead is seen to be bulging and infiltrated, an incision should be made at once through the tense tissues. A simple paracentesis or linear puncture, which may answer in the milder forms, does not always suffice in these cases, especially if the membrane is much swollen. The point of the knife should be made to enter at the upper posterior portion of the membrane, in the part which bulges most prominently, and, after penetrating as far as possible into the deep connective tissue, it should be carried far downward in a slightly curving direction. The utmost care should be exercised not to injure the ossicles. Before an incision is made the canal must be rendered as thoroughly aseptic as possible by first syringing with bichloride of mercury solution (1 to 2,000) and then swabbing the walls with alcohol. The surgeon's hands and instruments should be sterilized and every known antiseptic precaution should be used. After the incision has been made the ear should be cleansed of the discharge by the surgeon with sterilized cotton. The method employed by the author is to twist cotton on a holder, then to pass it through a flame before putting it into the canal. This is done at each visit, pains being taken to cleanse the ear very thoroughly. Between visits the nurse is instructed to renew the cotton in the ear as fast as it becomes wet through, each piece of cotton being handled with forceps and passed through a flame before it is placed in the meatus. In this way, so far as in the surgeon's power lies, every chance for infection from handling is removed. The ear is never syringed unless the discharge becomes decidedly purulent. Placing the patient in favorable surroundings, using whatever constitutional treatment may seem to be indicated, and caring for the ear in some such way as has just been described, establishes those conditions in which the disease is most likely to pursue an uncomplicated course. When the discharge becomes distinctly purulent and profuse it must be removed from the canal as often as it may seem best in any individual case—*i.e.*, from say three times a day to as often as every hour or two. The best manner of removing it is by gentle syringing, using warm water with sodium bicarbonate (a four-per-cent. solution), or a saturated solution of boric acid, or a bichloride solution (1 to 5,000). The sodium bicarbonate solution is the best, as it dissolves the mucus or renders it less adhesive, and at the same time is harmless. The bichloride solution should never be used in children on account of the danger of its passing through the Eustachian tube and being swallowed.

Solutions used in syringing the ear must always be warm and non-irritating, especially after the perforation has taken place. During the acute stage, previous to the establishment of a perforation, they should be used as hot as possible—the hotter the better. In some influenza cases, however, when there are numerous blood blisters on the drumhead and neighboring parts of the canal, the heat increases the pain. In such cases it is well to omit the douching and to apply ice over the mastoid, as cold affords greater relief.

After the discharge has ceased and convalescence is fully established, there is little to be done aside from the general care of the patient. But if the subacute stage is prolonged, some after-treatment of the middle ear, by inflations or by applications to the Eustachian tubes, may be necessary until the drumhead shall have resumed its normal position. These simple measures will generally be all that is necessary. There is danger of doing too much as well as too little. There is no condition that needs to be more carefully watched, both as regards the external parts and especially as regards the deeper portions of the canal and the drum membrane. At every visit careful inspection of these parts must be made, or an intelligent understanding of the case cannot be had.

Treatment of local conditions in the nose and throat is frequently necessary. When adenoid hyperplasia is present in the naso-pharynx the redundant gland tissue must be removed, as the ear disease cannot be permanently cured if it is permitted to remain. On the other hand, I have seen acute purulent middle-ear disease complicated with mastoid inflammation rapidly recover after operation for removal of adenoids.

After the period of active inflammation has passed the ear is apt to be extremely sensitive, and the patient should exercise the utmost care to avoid a recurrence of the disease, as relapses are frequent. And besides, in this disease a recurrence is especially apt to lead to serious consequences. A fresh cold, or a chilling of the body, during the active progress of the disease, is almost certain to develop disastrous consequences.

Sometimes the perforation closes before the discharge has ceased, thus necessitating reopening of the membrane. This procedure is frequently necessary when the disease has extended into the mastoid cells. The mastoid region should be constantly watched and tested by pressure over the antrum and tip, at each visit; and if there is the least sign of tenderness, after free opening of the tympanum, ice or heat should be applied. Cold applications are usually the most comfortable to the patient, but occasionally dry heat is better borne. If ice is used it can be applied by means of either the Leiter cooling apparatus (Fig. 1693) or the rubber bag devised by the author (Fig. 1692). This bag is to be filled with cracked ice every hour. It is securely closed by a metal clamp on the rim near the top. It is applied with the wide part over the mastoid, the clamped end uppermost, and the auricle protruding through the opening. It is held securely in place by tapes attached in the eyelets, and can be worn by the patient in either the upright or the recumbent posture. A piece of gauze or muslin over the surface next the skin will absorb the moisture which gathers on the surface and thus prevent wetting the skin.

Local blood-letting, in combination with the application of heat or cold, is very valuable. The leeches should be applied, one over the antrum and another over the tip. Usually the patient is then advised to go to bed, and for some reasons this is a good step for him to take; but the most important thing for him is to choose such a position of the head and body as will best conduce to good drainage of the ear and to relief of the congestion. The upright position, or one approximating to this, will be found to fulfil these conditions very closely.

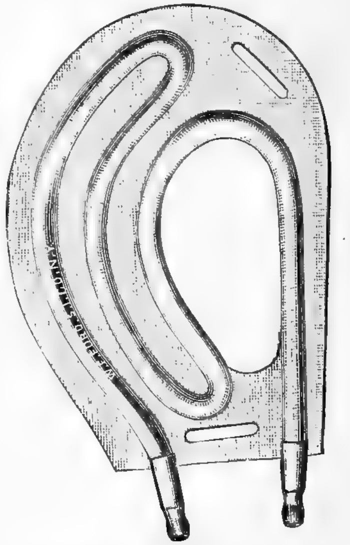


FIG. 1693.—The Leiter Cooling Apparatus, which affords a continuous flow of ice water through the coil.

The use of ice applications should not be kept up longer than for from three to five days, and they should be set aside just as soon as it becomes reasonably clear that the inflammation has abated; for while the ice undoubtedly reduces the congestion and consequently the pain and tenderness, yet it is possible for serious disease to be going on within the bone even when these symptoms are absent. At the end of two or three days the ice should be omitted for a few hours, and if the pain then returns it may be assumed that the disease in the bone is probably fully established, and operative interference should no longer be delayed. *Frank B. Sprague.*

EAR DISEASES: AFFECTIONS OF THE AUDITORY NERVE.—The study of the pathological processes involving the perceptive auditory mechanism is one attended by exceedingly great difficulties. Thanks, however, to the work of a constantly growing number of indefatigable workers, the mists which formerly obscured our vision of this region are gradually being dissolved, and we are seemingly warranted in hoping that in the near future we shall be in position to remove many of the affections of the auditory perceiving apparatus from the gloom of ignorance to the light of scientific knowledge, and the treatment of such conditions from an almost helpless empiricism to a position among the triumphal achievements in aural science. There will still remain many processes before which we shall continue to be helpless unless, happily, work along the line of prophylaxis may be productive of beneficent results. It is to be hoped that such shall prove to be the case. When one thinks that, until of late, fourteen per cent. of all aural cases were practically condemned to neglect and hopelessness, the incentive to renewed and tireless study of the diseases affecting this region is brought home to every ambitious and conscientious practitioner of aural surgery. For it is demonstrably true that in nearly fourteen per cent. of all aural cases the sound-perceiving apparatus is more or less deranged, either alone or as a complication. About ten per cent. of this number occur among children, and ninety per cent. among adults; the larger percentage of adults being due to the frequency of disturbances in the middle and internal ears combined. Uncomplicated disease of the internal ear is more common at the two extremes of life.

Congenital development of the parts specialized for the perception of sound is subject to variations from the normal. Thus, the labyrinth or the auditory nerve may be completely absent; such cases have been reported. Or, without going so far, there may occur an arrest in development, which most frequently affects that portion of the labyrinth called the cochlea. This arrest in development may involve both the osseous and the membranous labyrinth, or the latter alone. Fortunately, however, such congenital malformations are of rare occurrence. They are usually bilateral and of much the same degree on both sides. They may or may not be associated with similar changes in the sound-conducting apparatus. The hearing ability may be very little, if at all, impaired in those cases in which the defects are unimportant, but the more marked the defects the greater becomes the deficiency in hearing, even up to the total abolishment of the function.

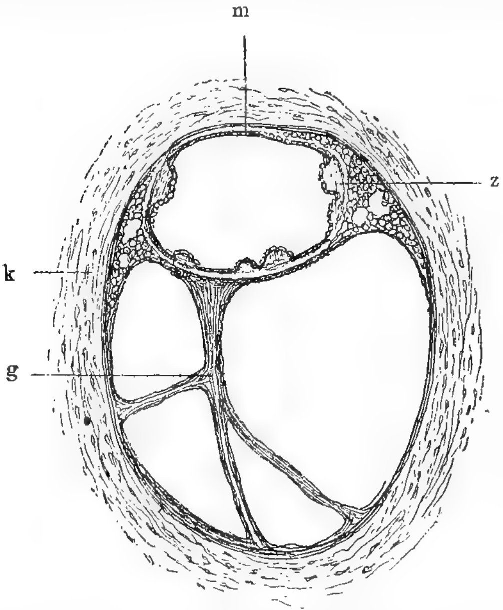


FIG. 1695.—Section of the Bony and Membranous Portions of the Semicircular Canal. (After Politzer.) *k*, Bony wall of semicircular canal; *m*, spot where the membranous canal is attached to the bone; *z*, mound-like irregularities of the inner surface of the membranous semicircular canal; *g*, vascular bands of connective tissue.

Acquired nervous deafness, if occurring in childhood, is usually unilateral, and probably is caused, in most cases, by overlooked infectious diseases, especially mumps, injuries to the skull, and hereditary syphilis; the last form, however, as a rule, is bilateral.

In taking up the pathology of this region, it is well to bring to the mind of the reader the difficulties which surround the investigator: the delicacy of the parts, the scarcity of material, and the amount of time and patience involved in the investigation. That so much *is* known is a matter for congratulation, and our thanks are principally due to such men as Politzer, Moos, Steinbruegge, Habermann, H. Knapp, Schwabach, Scheibe, J. Orne Green, Gradenigo, and Bezold.

First, there are disturbances in the blood-vascular supply of the parts. Thus, an oligæmic or anæmic or hyperæmic condition may exist with little or no alteration in the anatomical structures. Degenerative changes have, however, been attributed to prolonged anæmia or oligæmia, and it is certainly true that hyperæmia, if long continued, may cause increased pigmentary deposits (a moderate quantity not being considered abnormal),

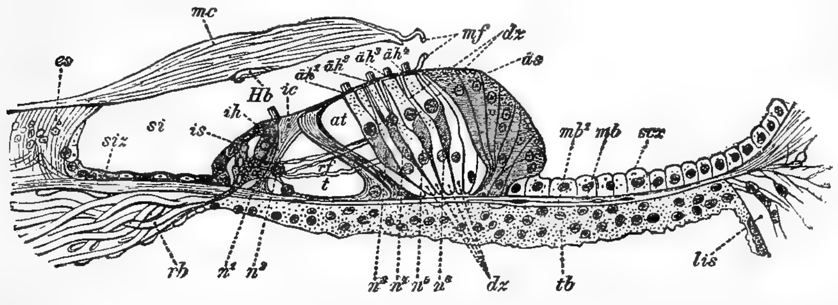


FIG. 1694.—Radial Vertical Section of the Papilla Acustica Basilaris or Corti's Organ, from the Middle Whorl of the Cochlea of a Man Twenty-nine Years of Age. (After Retzius.) *es*, Limbus laminæ spiralis; *mc*, membrana tectoria or membrane of Corti; *Hb*, Hensen's band; *mf*, fibres which attach the membrane of Corti to the basilar membrane: *si*, sulcus spiralis internus; *siz*, epithelium of the sulcus spiralis internus; *is*, inner epithelial or supporting cells; *ic*, inner pillars, the heads of which articulate with those of the outer pillars; *t*, the tunnel-shaped space under the arch formed by the junction of the inner and outer pillars; *ih*, inner hair or ciliated cells; *äh*^{1}, *äh*^{2}, *äh*^{3}, *äh*^{4}, four rows of outer hair or ciliated cells; *dz*, Deiters cells, intercalated between the outer hair cells; *äs*, Hensen's supporting cells; *rb*, nerve fibres of the Ranulus basilaris; n^1, $n^2 \ldots n^6$, outer twigs or the spiral nerve fibres; *rf*, radial nerve twigs which cross the tunnel-like space; *at*, inner portion of Nuel's space; *mb*, upper layer of the membrana basilaris; *mb*^{1}, lower layer of the membrana basilaris; *tb*, tympanal coating of the membrana basilaris; *lis*, ligamentum spirale.

calcareous deposits, hypertrophy of the membranous labyrinth, dilatation of the vascular structures, or serous saturation. Hyperæmia of great intensity may cause rupture of the vascular walls with consecutive hemorrhage. Such hemorrhages may occur in any portion of the labyrinth, with or without any pre-existing hyperæmia. Hemorrhagic extravasations, so formed, may either be completely absorbed, or become organized, or undergo fibrous or calcareous degeneration; may cause atrophy and degeneration of the epithelium, connective tissue, and nerve elements, with an abundant formation of granular cells, hyaline corpuscles, and pigmentary deposits; or may induce inflammatory changes terminating in suppuration. Under certain conditions, emboli may lodge in the labyrinth or infectious thrombi may form.

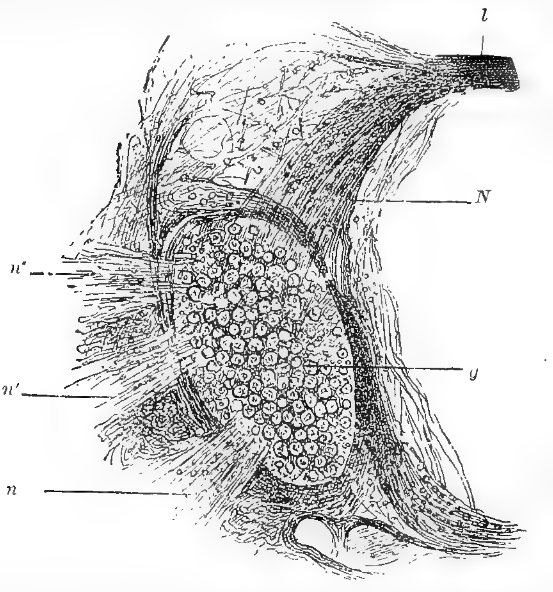


FIG. 1696.—Section of the Canal of Rosenthal and of the Ganglion Spirale. (After Politzer.) *g*, Ganglion cells of the ganglion spirale packed in the canal of Rosenthal; *n*, *n'*, *n''*, three separate nerve bundles of the cochlear branch of the auditory nerve entering the ganglion spirale; *N*, bundle of nerve filaments emerging from the upper pole of the ganglion spirale; *l*, entrance of this bundle into the lamina spiralis ossea.

The inflammatory processes that invade the labyrinth the writer has classified as hyperplastic (labyrinthitis hyperplastica) and exudative (labyrinthitis exudativa). In the former we may have hypertrophy of the auditory nerve stem, due to infiltration and proliferation of the neurilemma; deposits of calcareous salts or of amyloid bodies in and about the nerve; hyperostosis of the petrous bone narrowing the labyrinthine cavities; thickening of the periosteum; increased quantity of the perilymph and endolymph; infiltration with small cells and hyperplasia of the connective tissue between the membranous and the osseous labyrinth; a similar condition affecting the membranous labyrinth; development of osseous tissue from chronic inflammation of the labyrinthine periosteum; excessive epithelial growth on the inner side of the membranous labyrinth in chronic inflammation; chronic endarteritis; depositions of concretions of phosphate of lime and of corpora amylacea within the labyrinth.

In the exudative form of inflammation we have intense hyperæmia which may produce a serous saturation of the structures of the labyrinth; an infiltration with small lymphoid cells or round cells; a hemorrhagic exudation, as from a pachymeningitis hæmorrhagica; a purulent inflammation, due either to the direct propagation of pus from neighboring structures, or by way of the blood-vessels, or by the lymph spaces, or by dehiscences in the bony wall between the superior semicircular canal and the cerebral cavity, or to infection by the immigration of micro-organisms.

These inflammatory processes produce various alterations of the anatomical elements of the labyrinth: fatty degeneration of the endothelium of the blood-vessels, dependent upon an invasion of micro-organisms and causing coagulation and thrombosis and colloid degeneration of the labyrinthine tissues; injury of the acoustic nerve apparatus by hemorrhages or mycotic degeneration—the axis cylinders resisting longest; stasis and thrombosis of the periosteal blood-vessels; rapid destruction of the connective-tissue elements; and destruction of the osseous tissue through entrance of the micro-organisms into the periosteum, the bone corpuscles, and the blood-vessels of the Haversian canals. In addition, the poisonous products of metabolism, the toxalbumins, probably play an important part. The micro-organisms (streptococcus, staphylococcus, and Fraenkel's diplococcus of pneumonia) gain entrance to the labyrinth through the aqueducts, the periosteal blood-vessels, and, probably, also along the sheath of the auditory nerve, as does the pus. In the beginning, the perilymphatic cavity is almost exclusively the seat of the disease, which later extends to the endolymphatic cavity. The micro-organisms seem to collect and to develop their greatest working power in the most dependent parts of the labyrinth. The inferior portions of the cochlea are, therefore, most affected. Steinbruegge, however, thinks the proneness of the disease to localize itself in this region is rather due to the propagation of the affection from the cranial cavity.

As a result of the inflammation of the labyrinth, the nerve fibres, cells, and ganglia are destroyed or atrophied through pressure, their place being taken by newly formed connective tissue, or left vacant, thus forming a system of lacunæ corresponding in arrangement to the normal nerve distribution of the part; the membranous labyrinth may be totally destroyed, likewise the structures of the labyrinthine windows, with displacement of the stapes; coagulation necrosis of the labyrinthine ligaments may be produced, with consequent collapse of the membranous semicircular canals; the osseous capsule may be more or less destroyed. If the quantity or virulence of the infection be great, there may be absence of all tendency to reactive inflammation and to the production of new tissue.

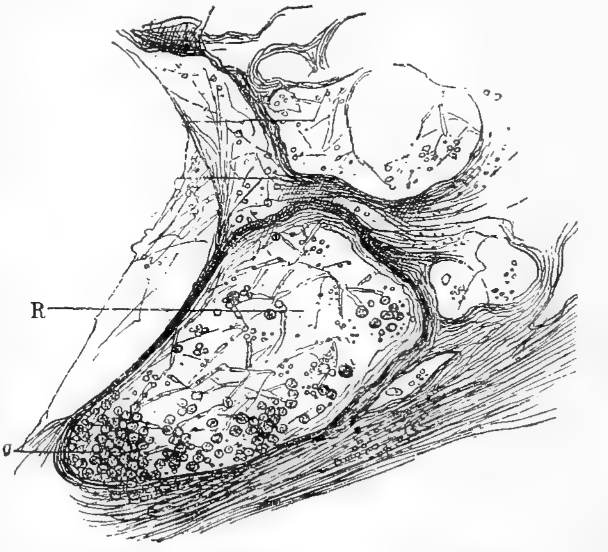


FIG. 1697.—Section Showing Atrophy and Disorganization of the Nervous Elements in the Canal of Rosenthal. (After Politzer.) *g*, Nuclei of ganglion cells in process of disorganization; *R*, canal of Rosenthal.

Should reactive inflammation be established, it results in the production of newly formed granulation, connective, fibrous, or osseous tissue; these new formations at times going so far as to produce complete obliteration of the labyrinthine cavities, of the foramina cribrosa, of the aqueducts, and of the oval and round windows. Ossification proceeds from the remnants of periosteum and from the newly formed connective and fibrous tissues.

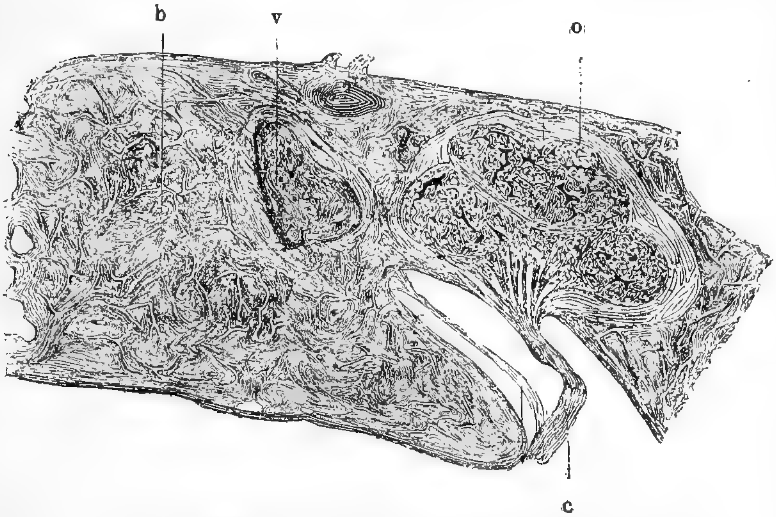


FIG. 1698.—Horizontal Section of a Cochleal Whorl, Showing the Results of Inflammatory Action. (After Politzer.) *o*, Cavity of cochlea completely filled with newly formed bone tissue; *c*, bundle of nerve filaments belonging to cochleal branch of auditory nerve; *v*, vestibule; *b*, entire absence of semicircular canals.

Among the pathological alterations of the acoustic nerve apparatus we will first take up changes in the stem of the auditory nerve. These may consist of the following: hyperæmia and ecchymosis; deposition of corpora amylacea or of concretions of phosphate of lime; fatty degeneration; gray degeneration; atrophy; leukæmic small-celled infiltration; purulent infiltration; embedding of the nerve in meningeal exudation. Tumors, principally sarcoma, fibroma, and so-called neuroma, may invade the internal auditory canal, exerting pressure, with consecutive atrophy, or even solution of continuity. The auditory nerve is more frequently the seat of morbid growths than is any other cerebral nerve. The changes most likely to occur in the region of the acoustic nerve origin in the medulla are due to thickening and purulent inflammation of the ependyma of the fourth ventricle and softening of the floor; effusion into the fourth ventricle, serous, aqueous, sero-purulent, or purulent, tumors in or about the fourth ventricle. Disease of the first and second convolutions of the left temporal lobe also interferes with audition, the cortical centre for hearing probably being located in this region. Of course, any pathological condition along the course of the cerebral acoustic nerve fibres also induces disturbances of function. Increased intracranial pressure may cause secondarily increased labyrinthine pressure with depression of Reissner's membrane and bulging outward of the membrane of the round window. Many cases, however, of increased intracranial pressure, as in chronic hydrocephalus, show no such change in labyrinthine pressure nor any impairment of the function of hearing.

The sound-perceiving apparatus is especially liable to be influenced by disturbances in the equilibrium of the system in general. Thus anæmia or oligæmia of the labyrinth occurs in connection with general anæmia, with continued fevers, with gestation and parturition, with aneurism of the basilar and atheroma of the internal auditory artery, with changes in the middle ear exerting pressure upon the labyrinthine structures through the round and oval windows.

Hyperæmia of the labyrinth occurs in all conditions producing congestion of the head: in conditions exerting pressure upon the venous channels of the brain (causing therefore obstruction to the return flow of blood from the ear), upon the vessels of the internal auditory canal, or upon the large veins of the neck; in disturbances of the circulation originating in the heart, lungs, or kidneys; in prolonged exposure to sharp sounds; and, finally, in the gouty or rheumatic diathesis. In the matter of the influence of prolonged exposure to occupation noises, as in the various trades, upon the labyrinthine structures, Cooseman, at the sixth International Otological Congress, presented the following conclusions as a result of his investigations: "All noisy trades are not necessarily injurious to the hearing. In order that they should be injurious the following conditions are necessary: 1. That the workmen should be predisposed to affections of the ear by the existence of lesions of the nose or pharynx, or else by inveterate addiction to alcohol or tobacco. 2. That the noise should be intermittent. 3. That it should be of a comparatively high-pitched tone." That such drugs as salicylic acid and quinine do have an effect upon labyrinthine conditions is well known, but just what this effect is was not determined with sufficient certainty until lately, when the experiments of Grunert, following upon and confirming those of Kirchner, would seem to settle the question in favor of the production of hyperæmia and extravasations of blood. Alt and others have found, on histological examination, that hemorrhages in the labyrinth sometimes result from exposure to compressed air, as in caissons. And, since Eichler's recent confirmation of Schwartze's clinical observations,—showing, as it does, that the congestion is the result of a reflex action, through the sympathetic, upon the vaso-motor nervous system of the labyrinth, rather than of a direct influence

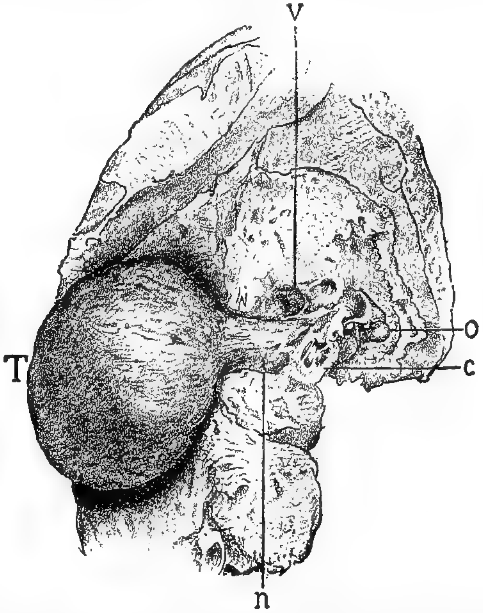


FIG. 1699.—Spinde-Cell Sarcoma of the Auditory Nerve, Growing into the Porus Acusticus Internus. (After Politzer.) *T*, Sarcomatous growth, the size of a walnut; *n*, extension of the same into the internal auditory canal; *v*, vestibule; *o*, tympanic cavity, with malleus and incus in place; *c*, cochlea.

through anastomoses—that form of hyperæmia of the labyrinth which occurs in connection with inflammation of the external or middle ear must certainly be considered here. Eichler found, as he claims, that the vascular supply of the labyrinth is entirely distinct from that of the surrounding tissues, and that the connection between the vessels of the tympanum and those of the labyrinth, which Politzer maintains, does not exist. Schwartze had long ago held that even in the very highest degrees of inflammation of the tympanum it is only exceptionally the fact that a simultaneous hyperæmia is met with in the labyrinth. It is a matter of observation that in chronic middle-ear suppuration with granulomata and polypi, the functional tests show no impairment of function of any importance in the sound-perceiving apparatus.

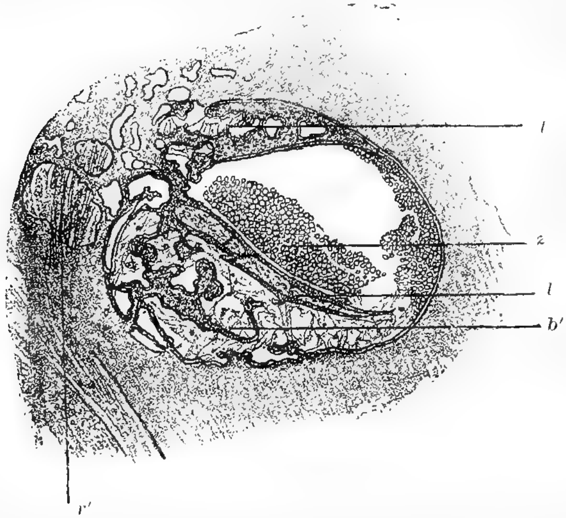


FIG. 1700.—Section of a Cochleal Whorl from a Deaf Person, Thirty-Two Years of Age, who had Died of Leukæmia. (After Politzer.) *l*, Lamina spiralis; *b′*, growth of bone and connective tissue in the scala tympani; *z*, leukæmia plaques in the scala vestibuli; *r′*, atrophied tissue of the ganglion spirale in the canal of Rosenthal; *t*, growth of bone on the medial wall of the scala vestibuli.

All conditions producing hyperæmia of the labyrinthine structures may enter into the causation of hemorrhages and ecchymoses. These may also be induced in the infectious diseases through changes in the vascular walls; in pachymeningitis hæmorrhagica; in leukæmia; in typhoid fever; in nephritis, gout, and rheumatism; in fracture or concussion of the skull; in diabetes, and sometimes in embolism of the arteria auditiva interna.

Atrophy and degeneration of the acoustic nerve apparatus may be caused by syphilis; by alcoholic excess; by any labyrinthine inflammation of sufficient gravity to interfere with nutrition; by changes in chronic otitis media exerting long-continued pressure on the labyrinth, and thus producing anæmia, which, if continued for a sufficient time, will result in nutritive changes of the nature of atrophy, and these secondary nerve affections may remain although the tympanic disease disappears; by acute hydrocephalus internus, leading to softening and shrivelling of the nuclei of the auditory nerve; and by fœtal ependymitis doing the same. Atrophy and degeneration may also occur in chronic hydrocephalus and in tumors of the brain and the nerve as a result of pressure; in the gray degeneration and atrophy accompanying tabes dorsalis; and in old age, through the presence of calcareous deposits and corpora amylacea. Finally, they may be caused by hemorrhage; by nephritis and influenza; by contraction of the basilar artery; by apoplectic and inflammatory processes involving the floor of the fourth ventricle; by professional concussion of sound; by purulent inflammation of the ependyma; by purulent inflammation of the stem of the auditory nerve from a similar condition of the meninges; and by emboli and embolic softening along the acoustic nerve tracts. Among the nerves of sense the auditory is the most "impressionable," that is, its function is more frequently impaired by general diseases and by chemical changes in the blood in infectious diseases. Affections of the auditory nerve attack, in the majority of cases, both organs of hearing. It is probable that degenerative processes involving one auditory nerve will in time pass over to the other. The view that atrophy of the auditory nerve can take place from inaction, as in ankylosis of the stapes, has not yet been corroborated by experience; in fact, the results of post-mortem examinations point the other way. The changes which occur in presbykousis and otitis media sclerosa seem to be due to a coincident trophic disturbance similar to that in the middle ear rather than to any atrophy from disuse. Central atrophy depends almost without exception upon cerebral disease, while the peripheral variety is most often a consequence of disorders of the auditory organ itself. The occurrence of the disturbances of hearing in these processes depends less upon the extent than upon the seat of the pathological accumulation.

Hyperplastic inflammation (labyrinthitis hyperplastica) may occur in syphilis, which is causative in most of the forms of this affection; in the first stages of exudative inflammation of the labyrinth due to infectious diseases, and the inflammatory process may advance no further; in gout and rheumatism; in rachitis; in typhoid fever and leukæmia; and in old age.

Exudative inflammation (labyrinthitis exudativa) may be caused by obstruction, in the internal auditory meatus, to the outflow of blood from the labyrinth; by typhoid fever; by leukæmia; by epidemic cerebrospinal, hemorrhagic, pachy- and simple meningitis; by syphilis, tuberculosis, measles, diphtheria, scarlatina, scarlatinal diphtheria, mumps, variola, and influenza; and by an extension from an otitis media purulenta of long standing. This form of inflammation occurs more frequently in children than in adults, because of the more frequent occurrence in children of the acute exanthemata, etc. Further, the anastomotic connections between the middle ear and the labyrinth on the one hand, and between the labyrinth and the cranial cavity on the other, are more numerous in children than in adults; and further, because in the child's ear, through the aqueducts, there is a freer communication between the labyrinthine fluid and the cerebro-spinal cavity than in the adult.

SYMPTOMATOLOGY.—*Functional Reactions in General.*—The normal limits of audibility lie between a tone of 16 v. d. (double vibrations per second) and one of from 20,480 to 27,361 v. d. Instruments that give 40,000 v. d. have thus far not been constructed, nor can tones of that pitch be heard. The low tone is obtained by the tuning-fork, and the high tone by the use of the Galton whistle or a modification thereof. A constant air current should be used to blow the whistle, and not a rubber bag or bulb, as is commonly the practice. The highest tones are produced with the Galton whistle at the mark 1.5, which represents about 20,000 v. d.

Before taking up the departures from the normal reactions to functional tests in diseases of the sound-perceiving apparatus, it is necessary to devote some attention to the normal decline in hearing evidenced in advancing age. Zwaardemaker has tabulated the average responses for the upper-tone limit at the different periods of life, about as follows:

Galton's whistle is heard under	10	years at the mark..	1.22
" " " from	20-30	" " " ..	1.39
" " " "	40-50	" " " ..	2.23
" " " "	over 60	" " " ..	3.03

A presbykousis (hearing of old age) may, however, be considered normal which is not lower than Galton 4.8. The lower-tone limit is elevated to about the same extent in old age. In old age the B. C. (bone conduction) does not alone experience a reduction, but sinks proportionately with the lessening of the hearing distance, the A. C. (air conduction), etc.

Commonly in diseases of the sound-perceiving apparatus, *the upper-tone limit*, obtained by means of the Galton whistle, *is lowered, i.e.*, the highest notes elicited by the whistle being denoted by one or fractions of one, and the lower notes by multiples of one and their fractions; as the obturator is withdrawn the note deepens or lowers at the same time that the indicator or graduated scale shows higher and higher numbers, and, therefore, a higher number on the scale—as, *e.g.*, 4.8—indicates a much lower note than a lower number, as 1.22. The *lower-tone limit by* A. C. (air conduction), as obtained by a clamped tuning-fork vibrating from 26 to 64 double vibrations in the second, *is impaired very little or not at all. The absolute duration of* B. C. (bone conduction), Schwabach's test, *is shortened or abolished* for all or for certain tones. A. C. > B. C. (air conduction is better than bone conduction), *both in intensity and in duration* throughout the musical scale (Rinné's test). If the disease is unilateral, *the vibrating tuning fork* C^2, placed *in contact with the vertex*, midway between the ears, *should* be heard in the unaffected ear (Weber's test); or in the better hearing ear, if the disease is bilateral. This test is not so reliable as those previously described. In labyrinthine disease the *patients hear the deeper tones of speech very well, while the higher tones are no longer perceived.* It is well, in testing with the whisper or speech, to remember O. Wolf's division of the voice sounds into:

1. The deep, like R and V.
2. The middle, like the explosives B, K, and T.
3. The high and strong, like S, Sh, and G; and the high and weak, like F, L, N, and H (which are excluded as dependent on other tones—tone-borrowing).

Wolf devotes particular attention to the consonants. Bezold employs the names of numbers as test words, as these are familiar to both children and adults. Equal intensity of sound can be obtained by using the reserve air left after a forced inspiration followed by a normal expiration. To test the hearing for speech thoroughly, it is quite sufficient in most cases, after testing a few words, to note the distance for those words perceived with the greatest difficulty.

It is well to remember that Bezold has observed a number of otherwise characteristic affections of the inner ear which showed a more or less extensive defect in the lower boundary of hearing; in addition, that not only the upper and lower ends, but also the middle portions of the tone scale, can be lost to hearing. But when defects exist in these portions the power of hearing speech is at the same time more or less completely lost.

Bezold has definitely settled the question, by very painstaking investigations, that after loss of portions of the labyrinth no remnants of hearing remain. Ears with defective labyrinths only reflect, more or less completely, the hearing conditions of the sound ears; thus proving that an ear without a labyrinth has no independent hearing power.

Disturbances of equilibrium are apt to be observed in any process that causes irritation of the nerve endings in the vestibule or the semicircular canals, or of the corresponding filaments in the stem or at the point of origin of the auditory nerve.

In testing for disturbances of equilibrium, it is well first to determine the static (the body at rest) equilibrium and then the dynamic (the body in motion) equilibrium. The author tests the former by means of an apparatus consisting essentially of a movable inclined plane, after the method of von Stein. A person with normal powers of equilibrium should be able to maintain his erect position—when facing toward the apex of the angle (anterior inclination)—until the board reaches an inclination of 35° to 40° to the horizontal. In posterior inclination, with the back turned toward the apex, the normal angle varies from 20° to 30°; in lateral inclination, with the side toward the apex, it varies from 37° to 38°. In patients with labyrinthine disease, giving rise to vertigo, etc., the angle measures 20° or less by anterior inclination, etc., and this is much decreased when the eyes are closed. The static equilibrium should also be tested with the eyes open and shut, with the legs close together, while standing on the toes, and while standing on one leg. A healthy person can stand in these positions for some time, with slight balancing, while the eyes are closed; but a person with imperfect powers of equilibrium immediately begins to show some disturbance of these powers. The dynamic equilibrium is tested by walking forward and backward on a level, by turning on the vertical axis of the body to the right or to the left with legs together, and, finally, by turning about on one leg alone. The last movement is the most difficult, but a healthy person can go through these various motions with little if any trouble; whereas aural patients with disturbance of the powers of equilibrium find it more or less difficult or impossible, and their movements are attended by great weariness. (See also article on *Equilibrium* and *Equilibration.*)

Given these reactions, the inference is well founded that we have to do with an affection of the sound-perceiving apparatus. Still other tests have been devised by Bing, Brenner, Gradenigo, Gellé, and others; but the above have been more universally tried, are sufficient for the purposes of diagnosis, and are more reliable.

The symptoms of affections of the sound-perceiving apparatus, as they are observed in various pathological conditions, are more particularly described as follows:

Anæmia.—There is usually some dulness of hearing, which is manifested either as a slowness of perception only, or as a real impairment of the hearing power. The impairment in the hearing ability follows along the line of the test responses as given above, being especially noticeable, however, in the curtailment of the duration of B. C. Annoying tinnitus of a low pitch is commonly present. The patient may be subject to occasional attacks of vertigo, and usually is the victim of general anæmia.

Hyperæmia.—There is very little if any impairment of the hearing power, and there may be present hyperæsthesia of the nerve to certain sounds. Often there is a feeling of fulness and distention in the ears or in the head, with dulness of intellect or even giddiness or vertigo at times. With this is usually associated a high-pitched tinnitus. The functional tests show a limited involvement of the sound-perceiving apparatus. Paræsthesiæ are likely to be complained of.

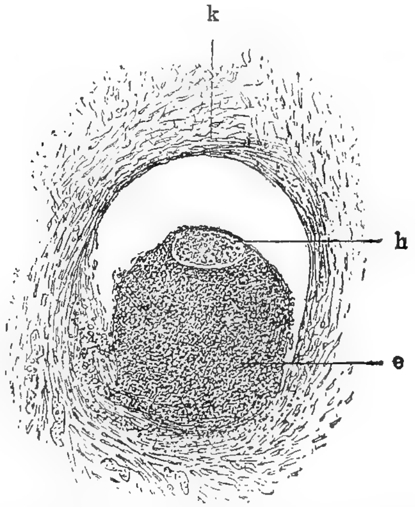


FIG. 1701.—Section of a Semicircular Canal, Showing Results of a Hemorrhage. (After Politzer.) *k*, Bony wall of semicircular canal; *h*, membranous portion; *e*, extravasated blood.

Hemorrhage is usually immediately followed by marked vertigo, aggravated on closure of the eyes, with possible falling or unconsciousness (the latter is rather rare) unless the hemorrhage is confined to the cochlea, in which case vertigo is absent. With or immediately following this occur nausea or vomiting, severe tinnitus (in some cases preceding the attack), occasionally profuse perspiration, and impairment of the hearing up to complete deafness. The symptoms thus given constitute what was formerly generally designated as Ménière's disease, and is the only condition to which that name should be given. Amelioration of these symptoms takes place in a short time, the vertigo, hardness of hearing, and tinnitus continuing longest. The hardness of hearing rarely disappears entirely, and the tinnitus is likely to persist, although diminished in intensity. There is always danger of a repetition of the hemorrhage. The functional tests give varying responses according to the locality and the extent of the hemorrhage, but always confirm a diagnosis of involvement of the sound-perceiving apparatus. G. C. Smith, in the Boston *Medical and Surgical Journal* for November 24th, 1898, thus describes a case of so-called Ménière's disease which he observed: "The patient, a man, sixty-two years old, in fair health, while sitting one evening in conversation, suddenly felt as though he was seized by some power and hurled a considerable distance, striking against the left side. He was unconscious for the moment, but arose with assistance. He was unable to walk on account of vertigo, and had to lie down. This was followed by vomiting and vertigo, which continued all night. There was also a hissing tinnitus, and on the following day there was deafness in the left ear. In the following five months he had six seizures similar to the first one. During all this time the noises in the head were continuous. The deafness, though incomplete, never improved after the first seizure."

The symptoms of embolism and thrombosis are presumably similar to those of hemorrhage. Thus Habermann, at the meeting of the German Otological Society held May, 1898, mentions the case of a man, fifty-three years old, who suffered one night from an attack of hemiplegia, which in a few weeks disappeared, with the exception of a slight weakness. Four years later, he had a relapse, with frequent attacks of tinnitus, vomiting, and deafness. The whisper was not heard on the affected side. The field of hearing embraced the tuning-forks from C^1 to C^7. The affection was probably of embolic origin, possibly in the brain along the course of the auditory nerve.

Serous effusions may give rise to the same symptoms, but more fleetingly. Rosenstein was the first to consider the possibility of an œdema of the auditory tracts causing disturbance of hearing in nephritic patients. Other authors also favor the assumption of a transitory œdema as causing transitory functional disturbance in parts of the brain.

Labyrinthitis Hyperplastica.—The most marked form of this inflammation is seen in connection with syphilis, usually as a late manifestation in the acquired variety, or around puberty in the hereditary, and gives rise to deafness, appearing gradually or suddenly, subject to periods of quiescence and exacerbation; it is also commonly accompanied by loud aural tinnitus. Vertiginous attacks and disturbances of equilibrium are usually slight unless the exudative form of inflammation is induced. The disease is likely to be accompanied by very violent headache, often nocturnal when due to syphilis. Both ears are usually affected. The sudden deafness coming on with serous saturation or lymphoid infiltration may disappear almost completely; but usually the hyperplastic formations are causative of a certain amount of permanent deafness. The functional tests leave no doubt as to the seat of the trouble in the sound-perceiving apparatus.

Labyrinthitis Exudativa in its most acute form comes on very suddenly, with perhaps a rigor; it is commonly associated with fever, nausea, or vomiting; with profound deafness, and marked derangement of co-ordination; at times, with stupor or delirium (although usually the mind is clear); with intense tinnitus and vertigo, and, in some cases, with pain. This very acute form occurs with epidemic cerebro-spinal meningitis (Voltolini described this form of inflammation as a primary inflammation, but there is not much doubt that it is an affection secondary to a more or less localized meningitis), with the acute infectious diseases (measles, scarlet fever, diphtheria, etc.), with epidemic parotitis, etc. Most of the symptoms abate or disappear in the course of a few days or a few weeks, but the staggering gait and deafness are more persistent, the latter rarely improving to any great extent. Functionally, the upper-tone limit is greatly lowered; B. C. is markedly reduced throughout the entire musical scale, or is destroyed for a part or for all of it; A. C. > B. C.; the power of equilibrium is much impaired. The less acute forms of exudative inflammation of the labyrinth give rise to vertigo (unless confined to the cochlea), to a sudden loss of hearing power, intense tinnitus, lowering of the upper-tone limit, with B. C. reduced or absent, and A. C. > B. C., and to disturbances of equilibrium.

Escape of Pus into the Inner Ear sometimes occurs in cases of acute suppuration of the middle ear and presents distinct symptoms. If it breaks through into the semicircular canals there will be vertigo, vomiting, disturbances of equilibrium, and nystagmus; if into the cochlea, great deafness. Nystagmus alone justifies the diagnosis. The pus may work its way indirectly into the upper semicircular canal from a subdural abscess. In chronic cases, Jansen states that the point of entrance is invariably the horizontal semicircular canal, but J. Orne Green presented three specimens at the 1898 meeting of the American Otological Society, in all of which the perforation was into the vestibule.

Labyrinthine Necrosis, according to Bezold, follows otitis media purulenta chronica, exceptionally otitis media purulenta acuta. Generally the inner cochleal skeleton, with either the entire first turn, or only a part of it, is the structure most liable to necrosis. There are two ways by means of which the otitis media purulenta may extend to the cochlea: (1) through the small cells which lie at the base of the tympanum and around the commencement of the Eustachian canal, and which surround the lower aspect of the cochlea; (2) into the cochlea through a perforation caused by rupture of the membrane of the round window. The sequestrum formation is very much more extensive in the early years than in later life. Disturbance of equilibrium with simultaneous tinnitus and occasional vomiting is generally present. Vertigo disappears with the extrusion of the sequestrum, and this symptom, taken in connection with the tinnitus and vomiting, may be regarded as an evidence of irritation of the nervous terminals in the ampullæ and sacculi; these symptoms may also be taken as marking the date for the extension of the middle-ear process to the labyrinth. Paresis or paralysis of the facial nerve is a constant symptom of labyrinth necrosis, and usually appears one or several months after the first attack of vertigo. It exists in from eighty to ninety per cent. of the cases, and is permanent in fifty per cent. In the other cases, the paralysis exists only for a short time and disappears before the sequestrum is extruded. Prolonged pain is a constant symptom, and is of such severity as to prevent sleep for weeks or even months; it also produces a poor physical condition and emaciation. This pain comes on from two to nine months before the expulsion of the sequestrum; it is at first felt in the entire half of the head and is accompanied by fever, vomiting, etc., probably due to meningeal irritation. Later, the pain becomes localized in the ear and takes on a more boring character. Preceding or at the beginning of the symptoms the otorrhœa becomes more profuse and is creamy and very fetid. Exuberant polypoid hypertrophies are present.

When *the Nerve Trunk is affected* the most prominent symptom is impairment of hearing. There are also present: tinnitus, vertigo, staggering gait, and excessive functional exhaustibility. Usually unilateral, it may be bilateral, as in tabes dorsalis. Hardness of hearing is generally most pronounced for the tuning-forks of middle register, perception for high and low notes being fairly well preserved. B. C. is very much impaired.

Word-deafness (sensory aphasia) furnishes the most reliable sign of involvement of *the cortical area*, usually of the left first temporal convolution. The function of both ears is usually impaired; tinnitus is more commonly absent; B. C. is reduced in duration.

Concussion due to Gun-firing occasions alterations chiefly in ears that were not normal before exposure. The perception by bone conduction is abbreviated, owing to over-irritation and subsequent exhaustion of the nervous portions of the ear. The field for tones is not contracted. Tinnitus, vertigo, and headache are not usually complained of, and, in the case of normal ears, very little permanent injury follows ordinary artillery practice. Permanent injury to the hearing is produced when the ear has been to some degree abnormal before the exposure.

Concussion of the Head may provoke symptoms indicating an involvement of the sound-perceiving apparatus, even up to complete deafness, and this latter may be induced without any recognizable changes being necessarily found in the labyrinth on post-mortem examination. The symptoms usually present are: diminution of hearing, tinnitus, vertigo, headache, unconsciousness, in some cases pain, occasionally acoustic hyperæsthesia or alteration in the pitch of certain tones, etc.,—one or all. These symptoms have been explained as due to shock to the acoustic nerve, or to basilar inflammation resulting from a blow, or to hemorrhage at the point of origin of the acoustic nerve.

Fractures of the Petrous Bone, involving the labyrinth, are accompanied by hemorrhage from the external meatus, or, if the tympanic membrane is not ruptured, the blood may pass through the tympanum and the Eustachian tube into the throat. As additional symptoms may be mentioned: a serous-looking discharge in considerable quantity; very pronounced subjective noises; disturbances of equilibrium and vertiginous symptoms; and facial paralysis in fifty-five per cent. of the cases. In both concussion and fracture the functional tests all show an involvement of the sound-perceiving apparatus.

Neurotic Disturbances of the sound-perceiving apparatus, which may be unassociated with pathological anatomical alterations, are by no means uncommon and are described below.

Acoustic Neurasthenia has as symptoms: impairment of hearing, varying from mere slowness of hearing (acoustic torpor or lassitude) to considerable deafness, especially marked under any prolonged strain or confusion of sound; mental anxiety, or extreme physical fatigue; and rapid improvement of the symptoms after rest. Tinnitus may or may not be present, and is increased by fatigue; paræsthesiæ are common, with great fluctuation of the ability to hear; the upper-tone limit is not apt to be impaired, but the duration of B. C. is lowered throughout the musical scale, and there is great functional exhaustibility of the acoustic nerve. Either one or both ears may be involved, though usually both are affected. The patients are generally neurasthenic, and any circumstance which aggravates this condition is the cause of marked decrease in the hearing. This condition is frequently associated with that which is next to be described.

Acoustic Hysteria is usually associated with great deafness which appears suddenly and is not subject to the fluctuations noticeable in neurasthenia; it remains the same throughout the continuance of the attack. Vertigo is never present and tinnitus is not frequent; one or both ears may be affected or the attack may pass from one ear to the other; paræsthesia or anæsthesia of the external auditory canal and the tympanic membrane may be present; functional tests are apt to be contradictory.

For example, D. Grant reports a case of hysterical nerve deafness with spontaneous recovery. A girl, aged eighteen years, was first seen May 27th, 1895. She gave the history of gradually increasing deafness for three years, the hearing having grown much worse after the extraction of some teeth three months before the visit. Only very loud conversation was heard. Watch heard at six inches; Galton up to the mark 3.8. B. C. diminished. Rinné's test positive. Tuning-fork hearing lost for C^2 and C^1, while for the other forks from C up to E^5 the amount of hearing power varied from three to fifteen per cent. Hearing returned, after a complication of ailments, in January, 1897.

Veit also has reported a case of hysterical deaf-mutism in a man of twenty-six years, who awoke a deaf-mute six weeks before he was first subjected to an examination. In writing he could very well make himself understood. Anæsthetic regions and palsies were missing. The deafness was absolute. Attempts to speak were followed only by inarticulate sounds. After letting him read the sentence, written by the physician before him, "You will hear again in a few minutes," he was catheterized with a good deal of difficulty, but hearing and speech returned at once.

Hyperacousis is an over-excitable condition of the acoustic nerve, sometimes even painful, occurring generally periodically in connection with great nervous or mental excitement or with neuralgia, or manifesting itself after the patient has partaken of stimulants. It also occurs in the incipiency of inflammatory affections of the ear.

Paracousis consists in the false perception of the pitch of a sound. *Paracusis loci* is the term used for designating inability to tell the direction from which the sound comes; it depends upon the difference in the acuteness of perception of the two ears. As our judgment of the direction of sound depends upon the binaural hearing, in unilateral deafness the apparent source of the sound will be projected in the direction of the normal-hearing ear.

Diplacousis is a form of paracousis in which a single tone is heard double; either each ear perceives the tone differently and it seems doubled (D. binauricularis), or a double perception of a single tone is got by one ear (D. monauricularis); the two tones differ from each other in time (D. echoica) or in interval (D. harmonica or disharmonica).

"*Nervous Tinnitus*" may exist as a pure neurosis without difficulty of hearing. It is observed as an irritable condition of the nerve in convalescence from severe febrile affections; also in connection with sexual excesses, intemperance, abuse of tobacco, over-fatigue of the auditory nerve, and extreme mental disturbance. It may continue indefinitely, the hearing remaining unimpaired.

Hallucinations of Hearing may occur in ear diseases without a changed condition in the brain.

Color-hearing is a term employed to define that phenomenon by which certain tones always excite in some people the sensation of color; certain sounds invariably inducing the perception of a definite color, which color is always the same for any particular sound. The cases fall into two groups: (1) A crude color sensation, often very beautiful, is associated with certain sounds, such as each of the vowel sounds, musical notes, or particular musical instruments; the appearance being usually that of a transparent colored film, similar to a rainbow, in front of the observer, but not obscuring objects; (2) color sensations are experienced whenever letters or written words (symbols of sound) are spoken or thought of, so that when a word is uttered the subject visualizes the letters, each of which has a distinctive tint.

Deaf-mutism.—One of the most important results of labyrinthitis is the production of deaf-mutism. In the United States there were about 38.2 deaf-mutes to every 100,000 inhabitants, but this proportion is apparently diminishing. They belong, to a great extent, by birth to those classes of society which are least favorably situated economically as well as socially. In the majority, the deaf-mutism develops before the end of the third year, but may develop as late as the eighth year. The pathological seat of the causative process is, almost without exception, in the labyrinth. In connection with the labyrinth, the middle ear is surprisingly often found to be affected—only exceptionally as regards lack of formation, but almost regularly by violent inflammation, generally of a purulent nature. Deaf-mutism occurs more frequently in the male sex. More than half the cases are due to acquired deafness, and epidemic diseases are probably most often the cause of the deafness. Bezold is probably nearly right in his statement that about forty-three per cent. are totally deaf, and it is the general opinion that among these the acquired cases are more numerous than the congenital. There is noticeably a very frequent occurrence of partial defects in the musical scale, in which sometimes the upper and sometimes the lower limit of tone is absent; sometimes single or multiple gaps or islands are found which show no perception of sound whatever. Only about 8.4 per cent. have hearing power sufficient for intercourse with other people. Disturbances of equilibrium (static or dynamic) are present in fifty per cent., and those showing normal equilibrium are also much more apt to have normal speech. Heredity exerts a great influence, especially in those families in which there are many cases of hardness of hearing, but direct transmission is usually absent, as Mygind found that not a single child of deaf-mute parents was itself deaf and dumb.

This is somewhat at variance with the findings of E. A. Fay, who has studied the marriages of deaf-mutes in America, and states that the marriages of congenital deaf-mutes give birth to more deaf-mute children than marriages of persons with acquired deaf-mutism in the proportion of 12 to 4.2 per cent. The number of deaf-mute children is increased if the deaf-mute's parents are relatives, especially if, besides themselves, there are other deaf-mutes in the families. Consanguineous marriages are causative only when joined to hereditary and other influences (as constitutional disease). Deaf-mutism is especially apt to occur in those families in which many children have been born in rapid succession. Gillespie has drawn attention to the frequency of goitre in deaf-mutism; and Lemcke, to that of affections of the nasopharyngeal tract, especially adenoid vegetations. The bodily growth keeps pace with that of normal persons, but there is defective brain development; as a rule, however, they are endowed with organic and mental sensitiveness but little inferior to the normal. They do not exhibit a higher mortality than normal individuals living under the same circumstances, but they are especially prone to lung diseases. Nearly half of all deaf-mutes over twenty years of age are obliged to fall back on the help of others for their maintenance. Marriages contracted by deaf-mutes exhibit a very small degree of fertility. (For further information on this subject, consult the articles on *Deaf-Mutism* in the present volume.)

DIAGNOSIS.—The diagnosis of diseases of the auditory nerve has been almost sufficiently indicated in the symptomatology, but there are a few points which it may be well to emphasize further.

In any case of hardness of hearing the first thing to be determined is whether the lesion is located in the sound-conducting or in the sound-perceiving apparatus. The antagonistic reactions to the functional tests may be tabulated as follows:

DISEASES OF THE SOUND-CONDUCTING APPARATUS.	DISEASES OF THE SOUND-PERCEIVING APPARATUS.
Upper-tone limit very little if any lowered.	Upper-tone limit noticeably lowered.
Lower-tone limit by A. C. elevated.	Lower-tone limit by A. C. not elevated.
Absolute duration of perception of B. C. increased throughout the musical scale.	Absolute duration of perception of B. C. diminished or abolished throughout all or in parts of the musical scale.
B. C. > A. C. both in intensity and in duration in the lowest part of the musical scale, and ascending with the gravity of the disease (Rinné).	A. C. > B. C. both in intensity and in duration throughout the musical scale (+ Rinné).
Weber's test heard in the diseased or the harder-hearing ear.	Weber's test heard in the normal or better-hearing ear.
Deeper tones of speech not heard; higher tones well heard.	Deeper tones of speech well heard; higher tones not heard.

In order to bring differing reactions more graphically before the eye, the author has arranged them below in the *schema* originally devised by himself. In this the normal reaction in the healthy ear is given for purposes of comparison; the numerals representing the duration of perception in seconds, the Rinné showing whether the respective forks are heard louder by A. C. or B. C. at the initial point.

In marked disease of the sound-conducting apparatus the reaction will be approximately as given below:

I. Average Normal Ear.

A. C.	A. C.	A. C.	A. C.	A. C.	A. C.	Rinné.
22 12	25 13	15 7½	33 13	32 13	22 14	Schwabach { B.C. A.C.
C¹	C	C¹	C²	C³	C⁴	Tuning-fork.
Galton $1\frac{5}{10}$.			Weber =			

II Average Case of Otitis Media Purulenta Recurrens.

B. C.	B. C.	B. C.	B. C.	B. C.	Equal.	Rinné.
0 14	8 14	8 11	13 17	15 16	13 14	Schwabach { B.C. A.C.
C¹	C	C¹	C²	C³	C⁴	Tuning-fork.
Galton 2.			Weber in the affected ear.			

In disease of the sound-perceiving apparatus the following reactions will serve as a type:

III. Average Case of Otitis Interna.

A. C.	A. C.	A. C.	A. C.	A. C.	A. C.	Rinné.
12 4	17 6	18 7	21 6	15 4	10 2	Schwabach { A.C. B.C.
C¹	C	C¹	C²	C³	C⁴	
Galton 2.7.			Weber in the better-hearing ear.			

In cases in which there is an affection of both the sound-conducting and the sound-perceiving apparatus, both upper- and lower-tone limits are contracted, the duration of B. C. is impaired, B. C. is better than A. C. (—Rinné) for the lower forks, while A. C. is better than B. C. (+Rinné) for the higher forks, and both the higher and deeper tones of speech are imperfectly heard. The degree in which one or the other apparatus is responsible for the hardness of hearing is indicated by the closeness of the resemblance of the results of the functional tests to the reactions given by the one or the other type of disease.

In the matter of locating the lesion in any particular portion of the sound-perceiving apparatus much has yet to be learned, but the following deductions seem to be well established as the result of post-mortem examinations of cases clinically observed before death:—Word-deafness points to involvement of the cortical areas; lower- and upper-tone limits fairly well preserved, with deafness for forks of middle register and greatly impaired B. C., indicate involvement of the nerve stem; disturbances of equilibrium may occur in the course of any pathological process that causes irritation of the terminal filaments in the vestibule or ampullæ, of the nerve fibres in the auditory nerve stem, or of the central origin of the nerve; pathological processes involving the cochlea alone do not induce vertigo; the cochlea is the only part specialized for the perception of sound, as the retina is for light, and its total destruction is followed by total deafness; it is probable that the lower notes are perceived at the cupola, and the higher notes at the base.

When the attempt is made to establish a diagnosis these deductions should be borne in mind while studying the results of the functional testing. At the same time it should always be remembered that it is often impossible to determine whether the disease is in the labyrinth, in the nerve trunk, or at some point in the intracerebral course of the nerve.

According to C. H. Burnett, anæmia of the labyrinth, causing deafness, tinnitus, and vertigo, may be diagnosed in two ways, viz.: by the temporary congestion induced by eating, and also by the inhalation of nitrite of amyl. If temporary improvement in all or any of these symptoms ensues after eating or after the inhalation of a few minims of amyl nitrite, the conclusion is that the case is one of chronic anæmia of the labyrinth.

In fracture of the petrous bone, the escape of cerebrospinal fluid is not essential, and no certain conclusions with respect to the anatomical situation, gravity, or the subsequent behavior of the fracture can be drawn from the external appearances in the ear and from the functional disturbances. In most cases both the internal and the middle ear are affected together. Fracture may occur without loss of hearing if the labyrinth is not involved in the fracture line.

The diplacouses are, in the author's experience, usually due to affections of the middle ear, as in a case recently observed of diplacusis echoica coming on during the acme of an attack of otitis media subacuta.

The neuroses are recognized by their symptoms and by the peculiar constitutional condition of the patient.

If the few remarks made above in connection with the subject of symptomatology are borne in mind, the diagnosis, according to our present knowledge, should not offer insuperable obstacles to the conscientious observer.

Prognosis.—The prognosis is always hopeful in those cases in which there has been no destruction of the anatomical elements, as in anæmia, neurasthenia, etc. On the other hand, it is always unfavorable in those cases in which such destruction has taken place. The condition remaining after a trial of treatment of moderate duration is apt to be the condition that will remain permanently, except in the case of hemorrhage, in which repeated attacks will tend to further impairment of hearing.

Amelioration may and usually does take place in the other symptoms, such as vertigo; but the hearing improves only so far as the anatomical elements develop recuperative power, and when that power is exhausted improvement ceases.

Treatment.—The treatment of anæmia of the labyrinth is in most cases practically that of the treatment of general anæmia, as in the anæmia and oligæmia following gestation and parturition; the condition is often temporarily benefited by doses of trinitrin, gr. $\frac{1}{100}$, two or three times daily. In the local anæmia due to aneurism or atheroma very little can be done; when it is due to pressure brought on by changes in the middle ear, operative interference to relieve that pressure should, if possible, be undertaken.

Hyperæmia, if acute, should be met by local blood-letting, purgation, and rest, while at the same time the diet is limited and stimulants are interdicted. The causative agency should always be searched for and corrected, as far as possible, on general lines. Regulation of the diet and bowels, curtailment or denial of stimulants, and correct ordering of the care of the body and method of life are always indicated and produce the best results.

Hemorrhages into the labyrinth should be treated, until the acute symptoms subside and absorption begins, by complete bodily rest, local blood-letting, purgation, hot foot baths, limitation of diet, and abstinence from the use of all stimulants, alcohol, tobacco, etc. Later, comparative rest and abstention from mental or physical work, with the regulation of the diet and bowels, will do more to favor absorption than the administration of drugs. The use of iodide of potassium in gradually increasing doses has given the best results in the author's hands. It may be employed conjointly with the other measures recommended, or independently, if for any reason they cannot be adopted. Pilocarpine has been strongly advocated by some authors; it should be given either by the mouth or hypodermatically, beginning with gr. $\frac{1}{8}$, two or three times daily, and increasing the dose until the physiological effect of the drug is obtained, when the patient is held to that dosage for a shorter or longer time.

In the hyperplastic form of labyrinthitis, regulation of diet and of the bowels, and denial of stimulants, counter-irritation over the mastoid, and attempts to provoke derivation and, most important, the attempted removal of the cause, are the proper measures to be employed. Resolution may be encouraged by the administration of iodide of potassium or of pilocarpine, if these are not contraindicated by the condition which caused the lesion or by the state of health of the patient.

During the acute stage of the exudative form of labyrinthitis as much should be done as possible to diminish the intensity of the attack and to limit the extension of the process. This in most cases amounts to very little. Rest in bed is imperative, limitation of the diet is advisable, cardiac sedatives and diaphoretics should be prescribed, the bowels should be regulated, and derivatives not contraindicated by the general condition should be employed. After the acute symptoms have subsided, resolution is to be encouraged by the continuance of rest, by the adoption of a light but nourishing diet, by the regulation of the excretory organs, and by the administration of those remedies which are known to have an effect on the pathological deposits and new formations—such, for example, as the iodide of potassium, mercury, pilocarpine, etc.

Jansen holds that when pus penetrates from the middle ear into the semicircular canals, the operative field should be extended so as to effect the removal of the horizontal or even the vertical canal with narrow chisels or with the electro-motor drill.

In labyrinthine necrosis the treatment, according to Bezold, should consist in systematic cleansing, insufflation of boric acid powder, and removal of granulations. A forcible extraction of the sequestrum before it is loose is not advisable. The mastoid process is rarely involved. A properly executed radical operation insures a safer recovery than if the sequestrum is spontaneously eliminated through a narrow canal, especially if signs of general disturbance are present. The result in six out of ten cases in which such an operation was resorted to, was complete recovery with epidermization of the cavity. Recovery probably also occurred in a seventh case. In one case there resulted atresia of the bony canal. One patient died from some complication in the other ear, and one died eleven days after the removal of the sequestrum, presumably of meningitis.

The regeneration of the affected nerve elements may be encouraged by the administration of the various nerve stimulants and nerve foods, such as strychnine, phosphorus, etc.

The principal treatment for concussion and fracture is rest and the meeting of symptoms as they arise.

The treatment of acoustic neurasthenia is, of course, that of the general neurasthenic condition. The general health should be improved by all the means at our command. The author has found that the feeling of well-being produced by the administration of gelsemium is a very important aid in inducing the patient to attempt and to adhere to those regulations which are necessary to the attainment of this much-hoped-for improvement; it should be administered in the form of the fluid extract. Strychnine has produced only a temporary improvement in the author's hands. The general health must be improved if any permanent betterment is to be attained, and gelsemium has the power of stimulating the ambition of the neurasthenic to the extent of accomplishing the tasks necessarily set for this purpose.

Hysteria requires administration of those remedies—pharmaceutical, psychical, and physical—usually recommended for use in the general condition.

The various other neuroses, reflex and otherwise, are to be treated from the standpoint of the cause.

It will be noticed that the subject of the treatment of affections of the sound-perceiving apparatus by means of electricity, phono-massage, and various other more or less imperfectly tried remedies has not been touched upon by the writer. The reason for this lies in the fact that the advantage to be derived from these remedies has been much doubted by very many competent otologists who have given them a fair trial, and that certain disadvantages in their use have been discovered in some conditions. Further attention needs to be devoted to them as remedial agencies.

The treatment of deaf-mutism consists in the removal of any curable pathological conditions found to exist in the sound-conducting apparatus, and in the improvement of what hearing power still remains in the sound-perceiving apparatus. Chronic suppuration of the middle ear is especially prevalent among those mute from acquired deafness, and should receive competent attention to prevent fatal results. Urbantschitsch has recommended systematic acoustic instruction by the pronunciation of vowels, consonants, single words, and sentences; the instruction to be given for a short time two or three times daily. Politzer is of the opinion that this may be the means of effecting a modulation in speech, but that the hearing cannot be affected thereby, because it has generally been lost through processes which have run their course and have left behind irreparable anatomical changes. Only children with a remnant of hearing should receive speaking exercises. Bezold and Koller deprecate the combined instruction of the half-deaf and the totally deaf, as it produces a waiving of the hearing remnants which the former still possess.

Henry A. Alderton.

EAR DISEASES: AFFECTIONS OF THE AURICLE.

—CUTANEOUS DISEASES. — Cutaneous diseases of the auricle differ in no essential particular from diseases of the skin involving other parts of the body, and are of interest to the otologist only because, in their localization at this point, he may be called upon to treat the lesion, and also because of the fact that some of these cutaneous diseases may extend to the epithelial lining of the external auditory canal, and give rise to deafness, or, in neglected cases, may extend into the deeper structures of the ear and give rise to grave complications.

Acne.—Acne of the auricle is rare and has no special characteristics to distinguish it from acne elsewhere.

Ecthyma.—Ecthyma appears in the form of large, single pustules with an infiltrated, hard, and elevated base, and flattened in the centre. They soon become covered by a dark crust which, after falling off, generally leaves a crater-like, round ulcer with sharp, slightly elevated margins; the surface of the ulcer is covered with a greenish-yellow scab under which the pus wells up on light pressure. Through the confluence of several ulcers, and the extension of the disease into the deep tissues, there may develop an extensive inflammation of the skin and cartilage. Barnick describes a case in which, in the edges of the ulcer, were many bleeding points ("ecthyma hæmorrhagicum"), as also an endarteritis of the blood-vessels of the skin. The base of the ulcer showed everywhere granulation tissue. In the microscopical preparations staphylococci and streptococci were found.

Eczema.—Eczema may occur in all parts of the external ear. It may be confined to the auricle, or the canal may also be involved; in some cases the affection may even extend to the dermal layer of the drum membrane. Eczema may occur idiopathically in the ear or it may extend from an eczema of the face or head. (The reader is referred, for further information in regard to eczema of the auricle, to the article on *Ear Diseases: Affections of the External Auditory Canal*, p. 620.)

Herpes.—Herpes of the auricle is rare, and occurs either in its simple form in connection with herpes facialis, or as a part of herpes zoster in the region supplied by the auriculo-temporal branch of the trigeminus nerve and the auricular branch of the third cervical nerve. In the first case it is the anterior part of the ear and the tragus which are affected, in the latter the posterior part and the lobule. Sometimes blebs are formed in the canal, and, very rarely, on the tympanic membrane. The outbreaks of herpes zoster are nearly always accompanied by neuralgic pains on the affected side of the head and in the ear, and at times even the mastoid process is painful. This symptom of pain in the mastoid was so marked in one case reported that the wrong diagnosis of mastoiditis was made, and the true state of affairs was not discovered until a short time before the proposed operation was about to be undertaken. The hearing is often impaired during the course of the disease.

As to the appearance presented by the disease when it involves the auricle, herpes of the ear differs in no way from herpes on other parts of the body. The watery exudation gradually becomes purulent or bloody, and after a few days desiccation takes place. Only exceptionally can the process assume a gangrenous character. Recurrences are not uncommon in simple herpes.

The treatment consists in the administration of narcotics when there is severe pain; in the use of powders or of compresses wet in cocaine solution, after the formation of blebs has taken place; in the use of white precipitate ointment; and, after ulcers have formed, in cauterization with silver nitrate.

Impetigo Contagiosa.—Impetigo contagiosa appears as a small red spot which soon develops into a pustule that may reach the size of a large pea. In course of time this breaks down and a crust is formed. By contamination with the pus new foci may develop, and so there may be found at one and the same time lesions in all the various stages. This disease assumes the character of an infection and is mostly epidemic. The neighboring lymph glands are swollen. Children are the chief sufferers from this affection, but adults are not always exempt.

The treatment consists in bathing with green soap and then applying zinc ointment, or an ointment of bismuth subgallate.

Pemphigus.—Pemphigus of the ear is not observed very frequently as an independent affection; it is more often seen as a part of the same general affection of the skin.

After a prodromal stage of lassitude and weariness, there follow fever and an eruption of discrete, slightly elevated, red spots on which develop bullæ distended with serum or blood. These may be of varying sizes, from the dimensions of a grape seed to that of a hazelnut. The bullæ burst and leave a red surface which is quickly covered over with new skin. Thus the disease comes to an end and the fever disappears. The disease may last for from one to two weeks, but it can drag along for a much longer time and may recur. In most cases healing occurs, but it is also possible for the affected parts of the skin to slough. We must regard pemphigus as among the infectious diseases.

The symptoms are extreme itching and a feeling of warmth, neuralgic pains in the face, tinnitus aurium, and a greater or less degree of deafness. The skin becomes scaly and as it peels it leaves the underlying skin more or less red, according to the length of time the lesion has existed.

The treatment is the same as for this disease in other parts of the body. The general treatment consists of cooling diet, rest, and the use of quinine or antipyrin. The internal administration of Fowler's solution is also sometimes indicated. The local treatment consists in a copious washing of the affected part with weak bichloride solutions, and the subsequent application of zinc oxide or boric acid, or of talcum powder finely powdered. In the more pronounced cases the scalp should be shaved in the neighborhood of the ear, the scales should be removed from the affected parts by thorough washing with green soap (sapo viridis), then a solution of nitrate of silver of the strength of two per cent. is to be applied, and finally zinc or ichthyol ointment should be used freely.

The prognosis is good.

Psoriasis.—Psoriasis of the auricle is very rare. It is characterized, as in other parts of the body, by a sharply defined, large or small efflorescence, with an infiltrated foundation covered with pearly epidermic scales. This is to be differentiated from other scaly skin diseases by the fact that in psoriasis the scales, when removed, leave a surface which bleeds and appears sieve-like.

The treatment does not differ from that of psoriasis in other parts of the body.

Seborrhœa.—This is an affection of the auricle of quite common occurrence; it develops especially in the hollows. It is less like the moist seborrhœa than the seborrhœa sicca, in which form of the disease the ordinary secretion of the sebaceous glands is hard and firm. The skin is covered with dirty, fatty, scab-like scales which undergo desiccation. There is no demonstrable anatomical change of the skin. The treatment is the same as for the disease in other parts of the body. Begin by washing the parts with tincture of green soap and then use a salicylic acid and sulphur soap made up with much fat. Constitutional anomalies must be taken into consideration.

Pruritus.—Pruritus very seldom occurs in the auricle. Romberg reports a case of itching in the left lobe. Every attempt to relieve this itching by scratching with finger nails brought on a severe attack of neuralgia of the first and second branches of the trigeminus. The treatment is the same as for the disease in other parts of the body. Salves are indicated: either the plain vaseline, albolene, etc., or vaseline combined with preparations of iodoform, iodol, carbolic acid, salicylic acid, or chrysarobin. Equal parts of chloral and gum camphor, rubbed together to make a viscid fluid, and applied to the part affected, will frequently relieve a pruritus when other measures fail.

ABSCESS.—Abscess of the auricle may occur in connection with skin affections, such as eczema, especially where pruritus is marked; the infection being conveyed by dirty finger nails or in some similar way. An abscess may also develop as a result of freezing or of an erysipelatous attack. Finally, it may develop from the sting of an insect or from a trauma of any kind, such as piercing the lobe, etc. Swelling, redness, pain, a sense of heat, and fluctuation are the symptoms which indicate the presence of an abscess of the auricle. The condition may become dangerous through a spread of the infection to the cartilage, thus causing a perichondritis. When a perichondritic abscess develops the cartilage is often destroyed, with a resulting deformity, or fistulæ may form.

Treatment.—An early free incision, curettage, and wet sterile dressings.

PERNIO; FROST-BITE.—In this affection we find various degrees of inflammation, according to the degree and the duration of the cold. The lighter forms are characterized by a bluish-red coloration, an ordinary amount of swelling, and very severe itching, which may increase to pricking pains. In other cases, which have resulted from exposure to a more intense cold, the auricle appears extremely swollen, very much reddened, and covered in various places with large blebs, whose contents are of a yellowish or bloody color. The pain is very great. The severest forms are seldom seen. In these gangrene develops; there is a black discoloration and abscesses form. Ultimately the ear shows varying degrees of deformity. Ears that have been frozen will continue to be sensitive whenever the temperature falls to a certain point. In these cases the swelling, the itching, and the formation of nodules, which may go on to form pustules and to ulcerate, often recur. In weakened individuals, especially young anæmic girls, frost-bites and chilblains are likely to develop at the beginning of cold weather.

Treatment.—In the lighter forms of freezing, cold compresses and poultices with Goulard's extract are sufficient; in extreme hyperæmia and swelling there should be a continuous application of cold by means of Leiter's coil. In regard to the itching and pain, relief may generally be obtained by the local use of tincture of iodine with the addition of tincture of opium. Afterward, ichthyol ointment should be applied. The following preparations will also be found useful: boric or zinc ointment; two per cent. silver nitrate salve; and orthoform vaseline. In the deep ulcers and also in exuberant granulations, silver nitrate stick should be used. Gangrenous parts should be amputated.

The ears should be protected from cold by ear muffs, and they should receive frequent washings with absolute alcohol. In anæmic cases the general health should be looked after.

ERYSIPELAS.—Erysipelas of the ear is of rather common occurrence. It takes its rise here either primarily, from injured or excoriated spots, or secondarily, from extension from the face or from the throat through the Eustachian tube and middle ear. The clinical picture, the course, and the termination are the same as when the disease affects other parts of the body. The auditory meatus, at least in the outer part, is generally involved, and occasionally the disease may extend to the membrana tympani. In those cases in which a perforation occurs the inflammation may extend from the middle ear to the mastoid cells.

Treatment consists in the use of ichthyol ointment, which both relieves the tension of the skin and keeps the infectious scales from being disseminated. Poultices with one-half to one per cent. bichloride solution have been recommended. Ordinarily the further spreading of the erysipelas has been prevented through frequent pencillings of the neighboring sound parts with strong tincture of iodine, or by scarifying them. The general condition and the complications demand suitable treatment.

GANGRENE.—Gangrene of the ear is seldom seen. Sometimes it affects the skin alone; at other times the cartilage is also affected; but there is always more or less extensive loss of substance. As causes we have a preceding wound or an abscess such as results from measles, erysipelas, or burning and freezing of the third grade. Urbantschitsch reports a case of Raynaud's spontaneous symmetrical gangrene in the upper third of the ear: it was caused by tropho-neurotic disturbances. In the majority of cases the inflammatory process is of long duration and depends on a disturbance of nutrition caused by thrombosis of the vessels. *Treatment* must consist in the removal of the necrotic tissue and in accelerating the formation of a line of demarcation. The last may be accomplished through the use of antiseptic poultices. Nourishing diet and tonics are indicated. Skin-grafting may be found necessary.

ULCERATION.—Ulceration may occur as a complication of burning or freezing; it is also observed in ecthyma, in herpes, in otitis externa diffusa, in diphtheria, and in gangrene. Such ulcers are generally seated on the tragus, the concha, or the lobule. They are superficial and they soon heal if suitable antiseptic dressings are applied. On the other hand, if they are allowed to become deep-seated, they are very hard to heal and are often the starting-point of a very severe eczema. Every eczema may give rise to numerous small ulcers. The most frequent ulceration of the auricle is due to syphilis.

The ordinary ulcerations do not extend to any great depth, and are covered with a yellowish, watery exudate. Those of a syphilitic nature present more marked characteristics; they are deep, crater-like excavations with sharply defined, indurated borders. They are often seen when the chancre has been overlooked. The favorite site of a secondary syphilitic ulceration is the hole pierced for the earring in the lobule; the mechanical irritation supplied by the earring at this point favoring the development of papular infiltration and the formation of small ulcerations on the anterior and posterior surfaces of the lobule. In tertiary syphilis, if the ear is affected by the ulcerative destruction of the gummatous new growths, the underlying cartilage is apt to become the seat of inflammatory action.

Primary syphilitic infection of the auricle has been seen and described by Zucker. The case was that of a man whose ear had been licked by a syphilitic woman. The auricle became greatly swollen, ulcers formed upon the anterior surface of the tragus, and the neighboring glands also became very much swollen. Occasionally the contamination of the ear with syphilitic secretion, as after contact with dirty hands or other infected objects, has caused a primary infection of this organ.

The *prognosis* and *treatment* of ulcers of the ear depend upon the causative factors.

DIPHTHERIA.—True primary diphtheria of the auricle has been observed in rare cases, but it generally occurs in connection with a previous or a simultaneous diphtheritic affection of the throat structures. Secondary diphtheria attacks the auricle by the infection being conveyed through an abrasion of its surface, or by direct extension from the throat, by way of the Eustachian tube and the middle ear. In such cases the auricle and the external auditory meatus are seen to be covered with the characteristic diphtheritic membrane, and when this is removed there will be seen large, irregularly formed, easily bleeding ulcerations of the skin. *Local treatment* consists in the application of antiseptic solutions and powders.

HYPERTROPHIES.—Hypertrophies are sometimes congenital, sometimes acquired. Under this heading are classed: nævus pigmentosus, nævus vascularis, and nævus cysticus; verruca vulgaris; cutaneous horns; those skin troubles which, starting in other parts of the body, affect the ear by extension or otherwise (*e.g.*, ichthyosis, scleroderma, and elephantiasis); and, finally, the thickenings which follow othæmatoma, perichondritis, the different inflammations, traumata, and freezing.

Nævus or mole, whether of the pigmented, the vascular, or the cystic variety, is a congenital anomaly which occurs with the growth of the body but causes no constitutional disturbance. It is seldom observed on the ear (Pipino). In old age the change of moles into malignant new growths (epitheliomata) has been observed.

The treatment is preferably surgical—excision and suture; the galvano-cautery, or the Paquelin cautery, or electrolysis may also be used.

The *wart* (verruca vulgaris) may be treated with fuming nitric acid, with concentrated carbolic acid, or with trichloracetic acid, or it may be removed by the galvano-cautery or excised with the knife or scissors.

The *cutaneous horn* should not be regarded as a neoplasm but as a pure hypertrophy of the skin. It is often scratched off by the finger nail, but when this happens the horn is generally reproduced. The use of the Paquelin cautery after the removal of these horns by the knife or curette, prevents their recurrence.

The hypertrophic skin diseases—ichthyosis, elephantiasis, and scleroderma—are very seldom seen as independent affections of the auricle. These cutaneous diseases, as a rule, affect the skin of the other parts of the body as well as that of the ear.

Ichthyosis.—Ichthyosis congenita is a very rare affection and never manifests itself on the ear alone. Under this heading are included those cases of intra-uterine hyperkeratosis of the entire skin which are characterized by increased formation and exfoliation of the lamellæ of the skin. In its growth the fœtus develops a skin absolutely like a coat of mail; the individual plates of skin being separated by deep furrows, as are the plates of a metal armor. This form of hypertrophy causes the skin of the fœtus to contract to such a degree that the mucous membranes are everted and brought to the outside (eclabium and ectropion). It is obvious that such a fœtus either dies in utero or in rare cases lives only for a short time after birth.

Elephantiasis.—Elephantiasis of the entire auricle has seldom been reported. In Haug's case the ear was very large, its measurements being as follows: circumference, 73 cm.; longitudinal measurement, 12.5 cm.; breadth, 7 cm. Histologically, it presented the characteristics of a lymphangiofibroma, in which there were rather numerous round cells, the result of the early inflammatory disturbance. Elephantiasis can occur after burns, freezing, and eczema, and after any kind of chronic inflammatory process, especially if an erysipelas develops on the site.

Aneurism.—An aneurism confined to the auricle alone or involving also the surroundings is rarely encountered. It may develop either spontaneously or under the influence of a trauma. The artery which supplies such an aneurism is either the auricularis anterior, the auricularis posterior, or the temporalis profunda. The symptoms caused by the presence of such an aneurism are a sense of discomfort, headache, and at times tinnitus aurium.

Angioma.—Angiomata of the auricle are of relatively frequent occurrence. They vary in size from that of a hemp seed or lentil to that of an egg. Their color varies from red and bluish-red to blackish-blue. They are soft, mostly flat, seldom round or provided with knobby prominences of the skin and subcutaneous tissues. They are observed on the anterior and posterior aspects of the auricle, on the tragus, at the entrance of the canal, and on the lobule—involving consequently the branches of the auricular, occipital, and temporal arteries. The smallest ones often manifest themselves as vascular nævi, which reach various degrees of development.

The angiomata of the auricle often remain unchanged in size for ten or more years. On the other hand, there are cavernous angiomata which grow with extraordinary rapidity, forming large knotty tumors. Most angiomata of the ear and its surroundings are congenital, but cases have been observed in which they have developed as a result of a burn or of freezing, as also from the effects of traumatism. A true aneurism only rarely originates in this way. Pedunculated angiomata are rare.

Injuries often lead to hemorrhages which are difficult to check; spontaneous bursting from momentary increased blood pressure, such as takes place during coughing, vomiting, etc., may occur. One case of death has been observed as a result of the bleeding from spontaneous bursting of a blood-vessel of the auricle.

The morbid anatomy of these angiomata is the same as that of other angiomata; that is, they are considered to be formations of enlarged blood-vessels with simultaneous thickening of the vessel walls, or they are due to the formation of new blood-vessels.

They are to be reckoned among the benign tumors only so long as the process of hypertrophy is confined to enlargement of the vessel walls and to formation of connective tissue. In this category belong the simple angiomata, the cavernous angiomata, and the angio-fibromata.

Malignant melanotic sarcomata develop at times from a nævus vascularis.

In the case of the smaller angiomata—those sufficiently large to be noticeable—the treatment consists in touching with the thermo-cautery or in excision; electrolysis may also prove to be an efficient remedial agent. Growths of greater size may be incised and a ligature then applied to the larger vessels, or they may be touched with the thermo-cautery. Injections of liquor ferri subsulphatis and such procedures are strongly advised against. Sometimes the larger angiomata can be excised *in toto*, especially if the chief vessels leading to them are easily accessible to ligature; this is particularly true in cases of aneurism.

Cysts.—Cysts develop for the most part in the scaphoid fossa of the ear, in the form of a soft, fluctuating mass. They contain a yellow, thin, sterile fluid, or one which is more or less tenacious in character; it is only seldom that they contain a purulent fluid. They are often found lying between the perichondrium and the skin, but generally they are seated between the two layers of the cartilage. Rupture of the cartilage seldom occurs. The duration is from a few days to many years. Microscopically, the cartilage shows hyaline degeneration.

Treatment.—In general, it is sufficient to incise the tumor and evacuate its contents; in some cases, however, it will be found necessary to resect the upper or both layers of limiting cartilage. Healing occurs in a short time, and with little or no deformity. The injection of a mixture of iodine and glycerin is a less certain method of effecting a cure, and the length of time required is also greater. Massage is even more uncertain in its results.

Othæmatoma (Blood Tumor).—Othæmatoma is an exudation of blood into the subcutaneous connective tissue, or under the perichondrium, or into the substance of the cartilage. Generally, the swelling appears suddenly on the surface of the auricle, in the antihelix or in the concha, and quickly reaches a certain size; in some cases it may be as large as a hickory nut, or it may even involve the whole upper two-thirds of the ear. The swelling, when the subcutaneous structures are alone involved, is hemispherical, fluctuating, with a smooth surface and at times a bluish color. The skin covering the tumor is intact. Fluid blood or bloody serum constitutes the contents of the mass. Where the extravasation is under the perichondrium the depressions and elevations of the auricle are definitely outlined. In many cases there is pain at the outset, but seldom are there other evidences of inflammation. Left to itself, an othæmatoma, in the course of time, undergoes absorption, or else it remains as a local thickening between the folds of the ear. If inflammation sets in, the symptoms may be quite severe; otherwise the only symptoms will be a change in the form of the auricle, a certain feeling of pressure, and—when the area involved is quite large—closure of the external auditory meatus.

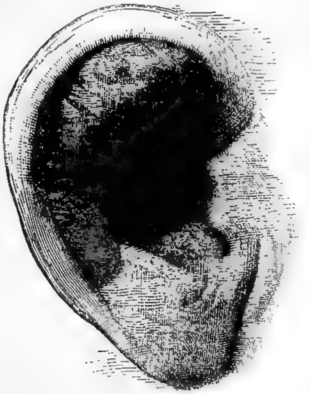


FIG. 1702.—Medium-sized Othæmatoma of the Auricle. (After Sexton.)

The treatment is expectant. Compression by bandage and massage hasten absorption. Puncture or incision is certainly not to be advised; only evidences of the formation of pus and necrosis furnish indications for surgical treatment, in which case evacuation of the cavity, with removal of any bits of necrosed tissue, is in order.

The greater number of cases of othæmatoma are found to be of traumatic origin, occurring in those whose ears are much exposed to injury—such as boxers and prize fighters.

In old, decrepit persons othæmatoma does occur without trauma, and is then due to atheromatous degeneration of the blood-vessels.

"Deformity of the auricle to a greater or less extent is nearly always a result of othæmatoma. Figs. 1703 and 1704 represent some of the strange and characteristic forms the organ may assume after healing takes place; they are the same, it may be said, whether occurring in lunatics or in the mentally sound. Obliteration of the sac is accomplished by the union of its walls, and where the perichondrium has been greatly stretched by extreme distention it contracts upon itself as reabsorption takes place, and adaptation to the cartilage as before cannot occur; the misshapen appearance of the cartilage increases with the continued contraction during the process of adhesion. The ear finally becomes indurated, the skin on the outer surface immovable. Sometimes the organizable lymph which obliterates the cavity enormously increases the thickness of the auricle, as in Fig. 1704; but where a thin plastic layer only intervenes the auricle will be reduced in size, and often become even thin and shrivelled, as in Fig. 1703" (Sexton).

In a few cases the hæmatoma is confined to the lobule alone. The disease develops in the form of a circumscribed, soft, purplish-red swelling, more or less sensitive to the touch. This swelling consists of a hemorrhage into the subcutaneous areolar tissue. Owing to the exposed position of the lobule it often the subject of injuries, but a simple hæmatoma is of very infrequent occurrence in this locality. Consequently, when we encounter this lesion in the lobule of the ear, we have a right to suspect that the blood-vessels of the part may be diseased, especially if any brain disease or some general disturbance of nutrition should be present at the same time. Hæmatoma may also occur as a purely idiopathic condition in conditions of mental health, even without a preceding traumatism.

The diagnosis is not difficult. The sudden appearance and the coloration make the confusion with angioma or neoplasms impossible. The disease, however, has been confused with perichondritis, but it is easy to differentiate between the two, since the latter does not occur in the lobule. The prognosis, for those cases in which there are no brain lesions, is good; in the others, it is not favorable, as the disease is apt to recur.

Treatment must be purely surgical. It should consist in incising the swelling, cleansing the cavity by curettage, and then packing it with iodoform gauze. Then at each change of dressing the cavity should be washed out with weak carbolic solution. The bandage should exert a gentle pressure. Healing follows without complications.

Perichondritis.—Perichondritis generally begins in the external auditory canal, with œdema of the tissues. As a rule it extends to the concha and thence over the other parts of the auricle, until often the whole organ is converted into an irregular, fluctuating mass, in which the folds and prominences of the auricle are obliterated. The meatus is stenosed and the lobule alone remains free from involvement, being separated by a sharp line from the other parts. An increase of the local temperature is present. The neighboring lymphatics are often involved and may become the seat of abscesses; at times, sharp, darting pains, with a sensation of heat, are referred to them. The fluctuating mass, which has formed in the course of a few days, contains a clear, serous, synovial-like fluid, which is never bloody as in the case of an othæmatoma; it soon, however, changes to pus. Throughout the whole course of the disease the cartilage of the ear escapes involvement, although here and there partial or entire loosening may take place. Tuberculous perichondritis of the auricle has been observed by Haug.

The course of the affection is either acute, lasting for from three to ten weeks, or chronic, lasting for the same number of months. Healing often occurs without any deformity, but in some cases there is a certain amount of shrinking. In rare cases ossification has subsequently taken place. The left auricle seems to be the more frequently affected.

Etiology.—The causative factor may be a local infection of the external auditory canal, or the disease may follow a general infection, as in the case of syphilis. In some instances it develops from a trauma or through extension from a furunculosis, from an otitis externa, or from a purulent affection of the middle ear. According to Haug the disease is sometimes of tuberculous origin.

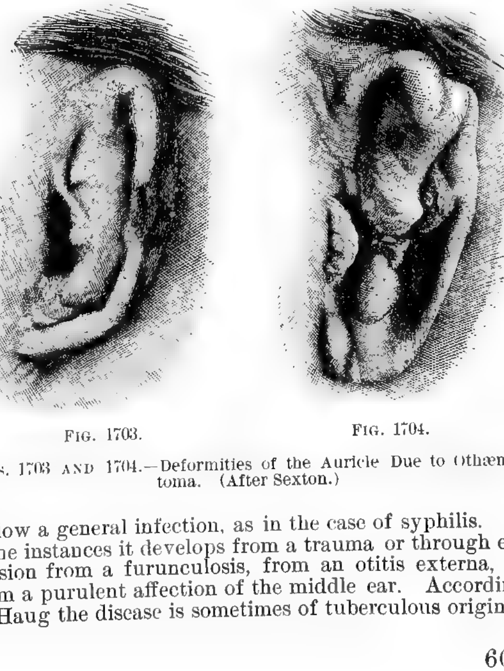


FIG. 1703. FIG. 1704.

FIGS. 1703 AND 1704.—Deformities of the Auricle Due to Othæmatoma. (After Sexton.)

The diagnosis is very easy to determine. The condition could be confused only with that of othæmatoma in its later stage, when sometimes the bluish-red color of the skin, which is dependent upon the presence of a bloody serous exudate, is succeeded by a paler hue, owing to the conversion of the latter into a transparent, syrup-like fluid. The previous history, the course of the disease, and the fact that the lobule is not affected in perichondritis confirm the diagnosis.

The prognosis is favorable, in that healing always occurs even if a deformity results.

The treatment consists first in energetic, local, antiphlogistic measures (ice-bags). If these fail to help, we may resort, in the early stage of the inflammation, to warm, wet compresses, and, if necessary, to incision. It is also a good plan, after making the incision, to scrape out the necrosed cartilage and the fungous granulations, to irrigate the cavity thoroughly with antiseptic fluids, to inject a mixture of iodoform and glycerin into the substance of the cartilage itself, and then to drain the wound with iodoform gauze. When there is a suspicion of tuberculosis, the infiltrated lymph glands must be extirpated.

Tophi.—Tophi are deposits of uric acid salts in the auricle; they are regarded as one of the earliest symptoms of gout. They appear here more frequently than in any other part of the body. They vary in number and in size. Sometimes they are white and contain a milky or creamy fluid; at other times they are as hard as little stones and are firmly attached to the cartilage by an inflammatory exudate. The patient afflicted with these deposits experiences, both before and during an attack of gout, a sensation of smarting and pricking in these nodules. In some cases these deposits will appear shortly after an attack.

Tuberculosis.—Tuberculosis has been observed in the auricle in the form of tuberculous ulceration and in that of a miliary skin tuberculosis (tuberculosis cutis).

Tuberculous perichondritis of the auricle has been described by Haug. It affects the concha, which is red and doughy to the touch. The neighboring lymph glands are also swollen and are sensitive to pressure. The skin over the swelling is somewhat red or bluish in color, but it may be pale; it cannot be indented. It must be borne in mind that these tuberculous nodules resemble fibromata, which are common in this region, and consequently a differentiation must be made between the two diseases. In general, these tuberculous nodules grow very slowly and only rarely show an inclination to soften and break through on the outside. According to Haug, nodular tuberculosis arises from an infection with tubercle bacilli in piercing the ears or by wearing earrings which were previously worn by tuberculous patients.

The disease, as in the ordinary perichondritis, is of slow development. If it is not operated upon, an abscess develops, after the lapse of a certain length of time, and tuberculous ulcers of the skin make their appearance. Then follow fistulæ through which necrosed cartilage can be felt with a probe. If the swelling is incised at an early stage and widely opened up, discolored pus and granulations containing tubercle bacilli will be disclosed, and the affected cartilage—sometimes in the form of a disconnected sequestrum—will also be seen. In cases that are not operated upon early the disease lasts for a period of many months and deformities of the ear often result.

The prognosis of nodular tuberculosis is relatively good, and if the nodules and affected glands are operated upon and removed early, a complete cure may be looked for.

Ossification of the Cartilage of the Auricle.—A few instances of this affection have come under observation. In these the cartilage was always found to be partially but never wholly affected; the upper part of the cartilage, the helix, the scaphoid fossa, the antihelix, and the fossa triangularis were the localities affected, while the tragus, antitragus, and lobule remained perfectly free.

Ossification does not seem to occur with special frequency at any particular period of life; it has been observed in persons as young as fifteen and in others as old as seventy-five. In a large proportion of the cases the change represents the termination of an othæmatoma; in still other cases a simple perichondritis has been observed to give rise to the deposit of bone. In many instances the cause is to be sought in trophic changes. These newly deposited bone masses possess all the anatomical features of true bone; the Haversian canals being surrounded by well-formed bone corpuscles, marrow, etc. The process goes on without visible appearance of inflammation and without the subjective symptoms of pain. Treatment is scarcely required. Knapp has in one case extirpated the bony cartilage.

New Growths.—The following benign new growths of the ear have been observed: angioma, atheroma, chondroma, chondro-myxoma, cysts (both serous and dermoid), fibroma, lipoma, nævi, and papillomata (warts).

Among malignant tumors the more important are the sarcomata in their different forms. The relatively benign fibro-sarcoma is found in the lobule as well as on the other parts of the ear. It is only by the aid of the microscope that a distinction can be made between such varieties of new growths as the angio-sarcoma, the chondroma, the cylindroma, etc.

The etiology of these growths is obscure. Scars, erosions, moles, a chronic eczema, a nævus, etc., may be the starting-point. Sarcoma of the auricle affects, as a rule, individuals under fifty years of age. The different forms vary as to the rapidity with which they grow. The canal is generally first affected, then the auricle. The round-celled sarcomata affect the auricle very seldom, while the fibro-sarcomata are the most common among the new growths of the ear. The primary nodule often remains for quite a long time relatively stationary until it receives some traumatism—the usual cause of a renewed activity of growth. This lighting up of the disease may manifest itself either in the form of superficial erosions, which bleed easily, secrete a thin serum, and have their edges markedly infiltrated, or in that of the rodent ulcer, which is of slow development and is situated in the skin and perichondrium. Lupus is often mistaken for sarcoma, especially when the characteristic lupus eruptions are wanting, and when, in the neighborhood of the ulcer, neither macular nor papular infiltrations are to be found. In both cases the neighboring lymph glands are swollen.

The sarcomata are therapeutically accessible only in the early stage, and they yield only to extensive excision; the use of caustics and all other means of treatment tend rather to accelerate their growth.

Another variety of ulcerative new growth is the carcinoma. In this variety the ulcer has sharp, bitten-out edges, beset with papillary excrescences, and its floor is covered with discolored, cheesy detritus. The viscid secretion that is given off has a most disagreeable and characteristic odor, and the destruction takes place very rapidly, so that not only the auricle but also the meatus, the neighborhood of the parotid gland, and the deep parts of the temporal bone are eaten away. The glands, even those far removed from the seat of the disease, show evidences of being involved.

In the benign, slowly developing carcinomas there is an abundant formation of connective-tissue stroma which gives a thick, tough structure. On the other hand, in the malignant type we have a stroma rich in vessels and in embryonic connective-tissue cells. In this variety there is developed a rich, thick layer of typical strings of cells which grow through the whole substance of the cartilage, and, after destroying the capsule of the cartilage, they take its place.

While the rodent ulcers can be removed by operation, even relatively late, with good results, in the case of the deep-seated cancers, unless taken at the very earliest stage, the involvement of tissue is so great that excision is not always practicable. In both cases the infiltrated lymph glands should be removed.

Noma.—Noma is a very infrequent affection and observed, up to the present time, only in ill-nourished, young children, especially after typhoid fever, the acute exanthemata, or diphtheria, and mostly in association with otorrhœa.

The diagnosis and prognosis are the same as for noma of the cheek. The disease is to be treated locally by daily applications of nitrate of silver, or by means of the Paquelin or galvano-cautery; the gangrenous parts are also to be removed with a curette. Constitutionally the treatment should be of a stimulating character, with a liberal diet.

NERVOUS AFFECTIONS.—*Anæsthesia of the Auricle*, in association with a similar condition of one side of the head, is one of the symptoms observed in cerebro-spinal meningitis, as well as in hysteria. It is generally associated with anæsthesia of the external auditory meatus. In the various affections of the middle ear the loss of the tactile and temperature senses in the auricle and its immediate vicinity is relatively frequent.

Hyperæsthesia.—This condition is observed much more frequently than is usually supposed. It is chiefly found in hysteria. At times it is noticeable in one spot and remains stationary, while at other times it spreads over the entire lobule and auricle.

J. Orne Green describes a case of hyperæsthesia which remained after an attack of herpes zoster.

Hubert-Valleroux observed a case which developed subsequently to an attack of tertian intermittent fever which had not been influenced by quinine. In this case it was found possible to ward off or control the attacks by compression of the carotid on the corresponding side shortly before the attack was expected.

Hyperæsthesia ought not to be confused with neuralgia of the auricle, nor with the pain which is a concomitant symptom of affections of the meatus, the middle ear, and the auricle.

Neuralgia.—Neuralgia of the auricle is an affection of rare occurrence. It is observed most often in connection with an herpetic eruption and is caused by some affection of the twigs of the trigeminus on the anterior surface and of the cervical plexus on the posterior. It is often attended with congestion and swelling. Pain is caused by slight pressure, while strong compression will sometimes cause the pain to cease.

Cramp of the Outer Ear.—Spastic contractions of the auricle occur very seldom. Romberg states as a reason that these muscles, in man, are only rarely voluntary. This condition has been observed after syringing the ear (Voltolini); on the introduction of a speculum and on the application of friction (Blau); as one of the symptoms of brain lesions (Romberg); as an aura preceding epileptic attacks without visible cause (Wolff); in cases of deafness, in strained attention (Schwartze); and, finally, as a symptom of habit spasms (Politzer). The branches of the facial nerve are always involved. Romberg cites a case of an old woman, forty-nine years of age, who, twenty-seven years previously, had suffered from an apoplectic attack with paralysis of the right arm, and in whom, after emotional disturbances, convulsions of both ears occurred, causing them to be rapidly wagged up and down. Tinnitus aurium and headache followed the attack. The case reported by Wolff concerned the retractors and the transverse muscles; the ear was dragged far backward and the muscles were felt to be hard and contracted, their contraction causing a pain which extended from the ears to the back of the head. Subcutaneous section of the muscles cured this case. Schwartze often noticed a quivering motion of the ears in the deaf when their attention was strained, and he noticed an instance of this in a boy of fourteen. In this case no other visible cause than that of intense attention could be discovered. The case observed by Blau concerned a boy of ten years, in whom every rubbing of the ear and every introduction of the speculum caused pain and a quick up-and-down motion of the ears, lasting for some minutes. The external application of the acetate of morphine (from two to ten per cent. with olive oil), stuffing the meatus with cotton, and the use of general constitutional treatment relieved this case.

The treatment must depend upon the cause. When such is not discovered, the treatment can only be symptomatic. Electricity, massage, and narcotics are to be used in such cases, but where they fail subcutaneous section of the muscles is indicated.

BURNS AND SCALDS.—Owing to their very exposed position the auricles often suffer from burns or scalds. This happens either through hot liquids being thrown at or falling upon the head, or, as is often the case, by the patient's falling accidentally, or being pushed, against a hot substance—a stove, steam-pipe, etc. All grades of burning are observed as in the case of other parts of the body. While these burns of the auricle are generally of a superficial character, Hartmann of Berlin has reported a case in which the damage inflicted was sufficiently severe to cause a perichondritis. (For further information in regard to this subject consult the article on *Burns.*)

INJURIES.—Superficial injuries affecting the auricle are to be treated in the same manner as those which affect other parts of the body. Neglect here, as elsewhere, is likely to lead to infection, and this in turn may cause a perichondritis. Parts of the ear which are severed must be very carefully sewed together. Cases have been reported in which the ear, after being entirely severed, has been sutured in its proper place, has taken a firm hold, and has healed without deformity. When this operation is performed, the surgeon must see that the meatus is kept open and not allowed to become closed by the formation of new tissue.

The artificial opening for earrings is apt to be torn through and a resulting inflammation may arise. A very simple plastic operation will correct the resulting deformity; for its performance, local anæsthesia will be found sufficient.

While othæmatoma may in certain cases, as before stated, arise without previous injury, it is dependent in most cases upon trauma of the ear. It is a noteworthy fact that othæmatoma is seldom seen in the army. In lunatic asylums, furthermore, it has become less frequent since the patients have received more humane treatment. The capacity for hearing is not very much lessened by injuries inflicted upon the auricle, even when the loss of substance is considerable.

CONGENITAL MALFORMATIONS.—Congenital malformations may be due either to an arrested or to an excessive development; they may be unilateral or bilateral.

Malformations due to arrested development include (*a*) absence of the whole or parts of the organ; (*b*) microtia (diminutive ear); and (*c*) congenital fistula. The cases belonging to the latter class are by far the most important, as a lack of development in other portions of the auditory apparatus is often found associated with this condition.

The external auditory canal, the membrana tympani, the ossicular chain,—one or all of these may be rudimentary or wanting, or the labyrinth may be only partially developed; and even the lack of development may include the maxillary, sphenoid, and palatal bones, and the structures of the throat. In some cases a lack of cranial development is found.

Gruber describes a case in which the right auricle was very rudimentary and the external auditory canal was entirely wanting. In addition, the following abnormal conditions were observed: The right half of the forehead was more prominent than the left; the left zygoma was smaller than the right; the right naso-labial fold was obliterated; the right eyeball remained partially exposed when the patient attempted to close the eye, and he was not able to wrinkle the skin of the forehead on the same side; the right side of the soft palate was lower than the left, and the uvula was drawn over to the left side; when the patient made an attempt at whistling, the mouth was drawn to the left; the sense of taste was normal; air entered the Eustachian tubes on catheterization; the watch was heard on contact; and the tuning forks placed on the vertex were best heard on the defective side. This case showed defective development of the peripheral portion of the facial nerve as well as a lack of development of the auditory apparatus and the zygoma.

Virchow, cited by Gruber, considers that deformities of the auricle are to be regarded as connected with faulty morphological development in the region of the first branchial cleft.

Congenital absence of the entire auricle is very rare, as some portion of the auricular cartilage covered with integument is generally to be found. Defects of particular portions of the auricle are more common and possess, except from a cosmetic point of view, but little pathological importance. In this category belong those cases in which the normal inrolling of the helix may fail to take place, and as a result we then have the ape-like auricle, or Darwinian pointed auricle; those in which the antihelix is larger than, and overrides, the helix—the "Wildermuth auricle"; and, finally, those cases in which the auricle is lapped over on itself ("cat's auricle"), with or without the growing together of the helix and tragus (see article in Vol. I., on *Auricle, Anatomy and Physiology of*).

Microtia is comparatively rare and the ear, though diminutive, may be well developed, or it may be malformed. When this latter condition is present it is often found that the malformation occupies some abnormal position, as in front of or below its usual location—a possibility which should always be remembered if an operation to form an external auditory canal is attempted.

Congenital aural fistulæ are to be found in front of the tragus or in the ascending portion of the helix; they are short blind canals lined with an epithelium which produces a white creamy secretion. They are liable to mild inflammatory attacks from closure of the entrance.

Malformations due to an excessive development include: (*a*) supernumerary appendages; (*b*) abnormal development of a part or of the entire auricle (macrotia partialis vel totalis); and (*c*) supernumerary auricles (polyotia).

Supernumerary appendages are most often seen in front of the tragus and are composed of reticulated cartilage with its coverings of perichondrium, subcutaneous areolar tissue and skin; such a structure must therefore be considered to be a true auricular appendage.

Macrotia partialis is not rare and is often found among the women of those races which wear heavy earrings. In such women the lobes are often to be found to be of an enormous size. *Macrotia totalis* is rare. *Polyotia* is extremely rare. Lauger relates the cases of two double-bodied monsters each of which had four auricles. The most frequent and most readily corrected of the malformations of the auricle are those in which the cephalo-auricular angle measures 55° or over. This latter condition is not always congenital, but is frequently caused by a faulty style of dressing the hair or of using strings in adjusting the headgear; for this reason it is more frequently to be found among women.

Prognosis.—In cases of malformed auricles, when there is an absence of an external auditory canal and the tuning fork is not heard by bone conduction, it is best not to attempt any operative interference unless it be for cosmetic reasons. In cases of unilateral deformity in infants it is almost impossible to state whether they hear or not, and it is therefore best to give an unfavorable prognosis.

Treatment.—In the correction of some of the above-mentioned defects otoplasty is of service, but its range is limited. It is often best, in a case of marked auricular deformity, to remove the entire auricle, with the exception of a stump to which an artificially devised auricle may be fastened. Supernumerary appendages may be removed. Congenital aural fistulæ must be opened and thoroughly exposed to view; the lining membrane must then be carefully exsected; and, finally, the whole cavity must be thoroughly curetted and the wound then allowed to granulate. Excessively large ears may be reduced in size by an operation of which the following are the two fundamental features: the removal of an elliptical-shaped piece of cartilage from the fossa of the helix, and the excision of a triangular section from the posterior border of the helix. The apex of this triangle should be located in the posterior portion of the concha. After the removal of these two portions of the auricle, the edges of the wound are to be united with fine interrupted silk sutures. For the correction of the handle-shaped ears, if the patient be young enough, pressure bandages applied for some time may suffice. If this does not accomplish the end desired, an elliptical piece of the posterior auricular fold should be removed and the edges of the wound united by sutures. In very marked cases it may be necessary to remove a small portion of the cartilaginous framework as well. In operating, care must be taken to have the cephalo-auricular angle the same on both sides.

In the so-called "cat's auricle" the holding of the auricle in a correct position by means of adhesive strips or bandages may remedy the deformity. At the same time, if adhesions are found to exist between the helix and the tragus, they will have to be cut through, and if the cartilage is not sufficiently flexible it may also have to be cut through along the line marking the folding. In some cases it may be necessary, in addition, to hold the auricle upright by denuding a small area on its posterior surface and a similar area on the side of the head, and then causing these two denuded surfaces to adhere together. Every case will call forth a certain amount of ingenuity on the part of the operator.

Robert Lewis, Jr.

EAR DISEASES: AFFECTIONS OF THE EUSTACHIAN TUBE.—The diseases of the Eustachian canal may be classed in two general divisions, viz., one in which there is more or less obstruction, and one in which there is more or less dilatation.

The obstructive class comprises by far the greater number of cases and constitutes practically all in which treatment is of use.

The obstructions are of two kinds: one in which the occluding element lies without the tube, and the other in which it lies within the tube.

The most common of the extra-tubal causes is the naso-pharyngeal tonsil (Luschka's tonsil, post-nasal adenoid, third tonsil, etc.), which is fully described elsewhere in this work. Let it suffice to say here that this tonsil, growing from the roof and sides of the naso-pharynx, may entirely cover the pharyngeal orifices of the tubes and absolutely prevent any aeration of the middle ear. From this extreme condition, found only in young children, there are gradations to so small an amount of adenoid tissue as to be harmless. Whether the occlusion be complete or partial, there is originally no attachment between the tubal prominences and the adenoid, but usually some attachment is soon formed by reason of continued contact or plastic inflammation. With the approach of adult life the glandular tissue of the adenoid, if not removed by operation, gradually gives place to connective tissue; and this, in turn, as it contracts, will, through the attachments just mentioned, draw the lip of the tubal orifice backward. Some degree of flexion is caused in this way and as a further result there is produced a degree of internal occlusion which may be even more serious than that due to the earlier pressure of the hypertrophied gland. In addition to its interfering with the functions of the Eustachian tube the enlarged Luschka's tonsil may retard its development.

There are still other external conditions which indirectly favor obstruction of the lumen of the Eustachian tube. The various pathological conditions located in the nasal cavities belong in this category. The tubal orifices lie in the track of the inlet through which air is supplied to the lungs. Anything tending to retard this supply of air causes a partial vacuum in the naso-pharyngeal vault; in other words, it establishes a condition in which suction is exerted on the mucous membrane lining this canal. Chronic hyperæmia and some measure of hyperplasia of the mucous membrane ultimately follow, and the calibre of the tube undergoes a corresponding degree of reduction.

All the acute febrile diseases of childhood affect the middle ear through the Eustachian canal, and, as a matter of course, involve the canal walls themselves. Of these diseases scarlet fever, diphtheria, and measles are the most troublesome. It is doubtful whether a direct spread of specific infection takes place, particularly in diphtheria; but there is intense congestion affecting the whole tract of the middle ear, as a result of which the Eustachian tube is occluded and all drainage from the tympanum ceases. The previous existence of a certain degree of tubal stenosis, due to hypertrophy of the adenoid tissue in the vault, serves only to aggravate the conditions produced by the febrile disease. The partial paralysis of the throat muscles, that so often follows diphtheria, sometimes also involves the tubal muscles. When deafness develops as a sequel of diphtheria, the possibility of its association with faucial paralysis—*i.e.*, with paralysis of the tubal muscles—should be carefully borne in mind. While it will scarcely be possible to establish a positive diagnosis, the probable dependence of the impaired hearing upon the cause in question may be inferred from the absence of tubal narrowing dependent upon a swollen condition of the lining mucous membrane. For example, gentle catheterization and inflation reveal the absence of any narrowing such as would be produced by a swollen mucous membrane, and yet the inflation improves the hearing to a noticeable degree. In the presence of this evidence we are warranted in drawing the conclusion that the habitual and frequent opening of the tube that results from the normal activity of the muscular fibres attached to it has been absent for a certain length of time, and that consequently the atmospheric pressure upon the outer surface of the drum membrane has during this period been in excess. Then again, the mere fact that the tubal prominences in the pharynx are covered with mucus does not warrant the inference that an exudative inflammation is present, for oftentimes the mucus, which is secreted at some other part of the naso-pharyngeal tract, flows down over the tubal orifices and so gives the appearance as if it were being secreted from parts situated higher up in the tubes themselves.

The other diseases which produce local lesions in the Eustachian tubes are syphilis, tuberculosis, smallpox, carcinoma and other varieties of new growths. Syphilis and smallpox may cause almost any degree of distortion, according to the location of the ulcer. The other diseases, on the other hand, may completely destroy the tubes and the surrounding tissues.

Foreign bodies are rarely encountered in the Eustachian tube. Bougies have been broken while in use and the distal fragment has been left in the tube. I have twice removed a pin from the tubal prominence of a patient who habitually carried several pins in her mouth in spite of repeated accidents. A man who amused himself by passing curved wires through his nostril and letting them slip past his palate into his mouth, came to my office in great distress because a wire had engaged in one of his Eustachian tubes. Particles of food are sometimes forced a little way into the tubes by vomiting. (See also the case mentioned by Dr. Sprague, on p. 591 of the present volume.)

The obstructions lying within the tubes are usually stenoses that have resulted from inflammations. These consist chiefly in hypertrophies of the mucous membrane and secondarily in hyperplasias of the submucous connective tissue. The lower ends of the tubes are most frequently affected, the upper ends rarely, and the central portions almost never. The stenosis at the lower end of the tube is caused by hyperæmia. This is induced in some of the ways already mentioned, and leads to a chronic thickening of the membrane. This may be said to be the intermediate link in the series of pathological changes which underlie chronic inflammation of the middle ear with its annoying subjective noises and associated deafness. It is often the condition that causes the patient to come for treatment. It must be relieved if deafness and a wide range of nervous disturbances dependent upon defective or perverted hearing are to be prevented. The degree of hypertrophy should be ascertained as accurately as possible by learning as fully as we can from the patient the past history of the trouble, and by making a thorough investigation—by digital exploration, by direct inspection through the anterior nares, and by aid of the rhinoscopic mirror—into the condition of the vault and nasal passages. Indirectly, inspection of the membrana tympani is, of course, valuable.

Treatment.—So far as hypertrophy of Luschka's tonsil is concerned, there is only one plan of treatment which is likely to be of much service, viz., the removal of all the redundant tissue by suitable surgical measures. These are described in detail in another part of this work, and it will therefore not be necessary for me to discuss the matter any further in this place. The same remark applies equally well to all the various procedures which are employed for the relief of hypertrophied conditions in different parts of the nasal passages, to the methods adopted for the removal of spurs of bone or cartilage from the septum narium, to the proper manner of introducing the Eustachian catheter, and to the plan of forcing air through the Eustachian tube into the middle ear by means of what is known as Politzer's method. There are a few matters, however, in regard to which I may speak without incurring much risk of repeating what will be stated elsewhere.

Electrolysis for the reduction of long-standing hypertrophies has many advocates. It is accomplished by introducing an insulated metal catheter, thoroughly polished and slightly oiled on the inside, and passing through this a gold probe with a smooth nodular end. The probe is connected with the negative pole of the battery, and the positive pole may be held against the side of the neck. When the stricture is reached, the probe is allowed to rest against it, and then an electric current of from two to five milamperes is passed for five minutes. No pressure whatsoever is to be used on the probe. It is claimed that, after a varying number of sittings, there will be no stricture for the probe to rest against.

Such diseased conditions of the middle ear as are accompanied by an irritating discharge may cause inflammation of the tube by the drainage which takes place through it. As the drum membrane is perforated in these cases, the tube may be washed with antiseptic and styptic solutions by filling the external canal with the desired fluid and forcing it through by pressing on the tragus as it is bent backward over the meatus. Pure alcohol and weak solutions of nitrate of silver may be thus used. They cause pain at the time, but much relief almost immediately follows. Polypi in the middle ear sometimes close the upper end of the tube. These or any accretions should be removed.

Dilatation of the tube is sometimes observed in connection with atrophic conditions. *Richard R. Daly.*

EAR DISEASES: AFFECTIONS OF THE EXTERNAL AUDITORY CANAL.—Malformations.—Malformations of the auditory meatus are usually combined with congenital defects of the auricle and middle ear, sometimes with arrest of development of the bones of the head (Mich. Jaeger, Moos, Zuckerkandl, Steinbrügge, and others). Contractions of the canal, complete closure, osseous or membranous (congenital atresia), and entire absence of the auditory meatus, represent the three different degrees of congenital defect.

In place of the external orifice of the ear there may be a shallow depression, or a short blind canal, or a very fine canal extending inward for some distance beyond the narrow, funnel-shaped cartilaginous portion. The canal may be uniformly narrowed throughout its extent, or constricted near its middle like an hour-glass, or the principal contraction may be near the membrana tympani. Congenital bridge-like bands of connective tissue crossing the meatus have been described by Moos ("Klinik der Ohrenkrankheiten," p. 85). Abnormal width of the meatus, amounting to deformity, is sometimes a congenital condition.

Some instances of *double meatus* are known; these are to be referred to an arrest in the closure of the first branchial cleft (Schwartze). In Velpeau's case one canal terminated at the drum membrane; the other, situated farther back, in the mastoid process; the two canals may also communicate before reaching the drumhead. Up to the fourth year of childhood an ossification gap exists as a normal condition in the anterior lower wall of the meatus.

Congenital closure of the meatus, even when complete, is not incompatible with a useful degree of hearing, provided the development of the labyrinth be normal. Operative interference for the relief of congenital atresia is justifiable only when the closure of the canal can with certainty be proved to consist of a thin septum, when speech can be understood through the ear trumpet applied to the closed part, and when the Eustachian catheter and otoscope have demonstrated the existence of a tympanic cavity. It follows from this that operable cases of congenital atresia are extremely rare.

IMPACTED CERUMEN, HYPERSECRETION OF THE CERUMINAL GLANDS.—The secretion of the ceruminal glands is, under perfectly normal conditions, probably never retained to the extent of impairing the function of hearing, but is gradually removed toward the exterior, and finds its way out of the ear, partly in consequence of the movements of the jaw, which are communicated to the meatus, partly from the natural outgrowth of the epithelium lining the meatus (Blake), and, finally, in consequence of certain manual operations. These processes are, however, not infrequently unavailing, and the cerumen remains in the meatus, forming a plug which blocks up the canal and causes a mechanical impairment of hearing. An accumulation of cerumen is promoted in various ways: 1. It is favored by hypersecretion of cerumen. Anything which induces persistent hyperæmia of the auditory canal may lead to this result. In some cases the cause of the hypersecretion cannot be recognized, but may fairly be assumed to depend on some trophic disturbance in the glandular secreting apparatus. Then, again, in a certain number of cases, a thin, rather copious secretion from the meatus (evidently from the ceruminous glands) occurs. More often, however, there is an absence of cerumen, as in many cases of chronic sclerosing otitis media. These two opposite conditions are evidently due to trophic causes. 2. Contraction of the meatus, especially the well-known partially collapsed condition of the cartilaginous meatus incident to old age, is another favoring condition. 3. Still another favoring factor is to be found in the abnormal nature of the secretion, which sometimes acquires a tough, adhesive property, and readily becomes matted with exfoliated epidermis and the hairs of the cutis. 4. Foreign bodies in the external meatus furnish a nucleus around which cerumen accumulates, until a plug is formed. 5. Finally, the impacted condition is favored by misdirected efforts at cleansing the ears. Thus, for example, in washing the ear a certain amount of moisture is introduced into the canal, and then this is followed by the insertion of a pointed piece of the towel, or, what is still more mischievous, by the use of the so-called aurilave or ear swab.

It is well to remember that ceruminal plugs are frequently met with in persons suffering from chronic middle-ear disease. Such accumulations are apt to be dry and hard; after their removal there may be little or no improvement in the hearing power, to the great disappointment of both physician and patient. So long as even a small space remains free, ceruminal plugs do not materially interfere with the function of hearing; but if the plug presses upon the membrana tympani, or if it suddenly becomes swollen, as in washing, or from free perspiration, so as entirely to occlude the lumen of the canal, discomfort and hardness of hearing ensue. It is owing to the latter reason, as the writer believes, that he has met with impacted cerumen much more frequently in the months of July and August than at any other season of the year.

Symptoms.—Temporary attacks of deafness, coming on suddenly and lasting for a few hours or days, and as suddenly passing off, are a very common symptom of impacted cerumen. At such times there is apt to be a feeling of fulness and confusion, with subjective noises in the ear, and a disagreeable resonance of the subject's own voice. Reflex phenomena such as cough of a spasmodic character, which in turn may induce laryngeal congestion, sometimes mislead the physician as to the real nature of the affection, and not a few cases have been reported in which epileptiform seizures have been traced to the presence of impacted cerumen, or of foreign bodies in the external auditory canal. Temporary impairment of the function of the other ear is also claimed by some to occur as a reflex condition in consequence of impacted cerumen. Vertigo, mental depression, and neuralgic pains sometimes occur. When pain has been at all a prominent symptom, circumscribed excoriation or inflammation of the auditory canal or membrana tympani is not uncommonly found after removal of the accumulation.

Impacted cerumen of itself never gives rise to total deafness. If in this condition speech cannot be understood, there is probably serious disease of the middle or internal ear. Complete occlusion of the canal, and contact of the plug with the membrana tympani, may, however, occasion great hardness of hearing, lasting in some instances for months or years, before efficient steps are taken for its removal. The presence of impacted cerumen alone probably never occasions serious injury to the walls of the auditory canal or membrana tympani. Enlargements or irregular dilatation of the meatus, with more or less destruction of the drum membrane, belong to other morbid conditions—*e.g.*, antecedent chronic suppuration, with the subsequent formation of laminated epithelial plugs (a somewhat rare condition to be described presently).

Diagnosis.—In connection with the above-mentioned symptoms, the meatus is seen, by speculum or naked-eye examination, to be plugged with a dull yellow, brown, or black mass which has a dull or glistening surface. If touched with a probe the mass is found to be soft and sticky, or doughy, or of stony hardness. Various foreign substances in the meatus, covered with cerumen, are apt to be mistaken for ceruminal plugs.

Pathology.—Cerumen is commonly a rather soft and somewhat oily, saponaceous substance readily softened with warm water, but when combined with a large amount of epithelium, or when very much desiccated, the mass may present considerable resistance to the action of water. After the removal of an impacted mass of long standing, it is sometimes found that its inner extremity presents a tolerably perfect impression of the membrana tympani. The walls of the canal rarely show any considerable departure from the normal; in some cases the surface of the skin is completely covered by layers of desquamated epithelium. Small unsuspected foreign bodies in the meatus, becoming coated with cerumen, may form the starting-point of an accumulation containing a large percentage of oil or fat.

Treatment.—All that is usually required for the removal of the impacted cerumen is a syringe and warm water, or, better still, a warm, weak solution of the bichloride of mercury. The syringe itself should of course be aseptic, and the precaution of using an antiseptic solution is recommended because it is impossible to tell beforehand whether the fluid used may not enter the drum cavity through a perforation or an accidental rupture, and thus light up a dormant septic process. In any case the fluid used should be lukewarm. If it is too hot or too cold, sensations disagreeable to the patient may result. The use of scoops, probes, curettes, and forceps, as a means of clearing the auditory canal, may, in the hands of persons thoroughly skilled in the manipulation of aural surgery, be permitted; otherwise such instruments should not be employed, except within the limits stated below. To syringe the ear effectually, a large vulcanite syringe should be used. The instrument should be capable of containing at least two ounces, and should be provided with a ring for the thumb on the end of the piston rod, and with a flange for the fore and middle fingers at the heel. Slight manipulations of the mass with a silver probe often greatly facilitate the action of the water from the syringe. The small vulcanite syringes, sold in the shops for ear syringes, are very inefficient, and cheap glass syringes are simply useless for this purpose.

In syringing, the patient's head should be held erect, the clothing should be protected with a towel, and a vessel such as a glass finger bowl should be pressed firmly against the integument below the auricle. In order to throw a stream of water effectively into the auditory canal, the general inward, forward, and downward direction of the canal must be made uniform by exerting gentle traction upon the pinna, with the left thumb and forefinger, in a direction upward and slightly backward. The force used may be considerable, but never sufficiently great to cause actual discomfort. Some dizziness, however, may unavoidably result from the operation.

The point of the syringe, which should be rounded and smooth, but not so large as to fill the orifice of the meatus, should rest lightly against its upper margin and should point in the same direction as that of the straightened auditory canal. If these precautions are observed, the stream of water will pass along the upper wall of the canal and force the obstruction out below the point of the syringe. From one to four injections will ordinarily suffice to remove the impaction. After two or three injections, it is often advisable to examine the ear and, if necessary, move the mass a little with the end of a probe to facilitate its removal with the syringe and water, as stated above. In ordinary cases impacted cerumen can and should be removed at one sitting.

In otherwise healthy ears, the function of hearing is, as a rule, restored immediately by the removal of the ceruminal accumulation, and the subjective noises cease; occasionally, however, several days elapse before a feeling of perfect relief is obtained. On the other hand, many persons immediately perceive all ordinary sounds with unusual distinctness for some hours after removal of the impacted mass. After syringing, the meatus should be lightly closed for a few hours with cotton wool. A recurrence of the ceruminal accumulation may be expected to take place after an interval of several months or years, occasionally at intervals of even a few weeks.

A want of ceruminal secretion, with undue dryness of the ears, is usually symptomatic of chronic middle-ear disease; if it is attended with itchiness, painting the meatus with some softening substance, such as vaseline, affords a certain degree of relief.

Laminated Epithelial Plugs (*Keratosis obturans*, Wreden, Burnett).—Occasionally, the meatus is found obstructed with a mass which at first sight resembles an ordinary ceruminal plug, but the use of the syringe only brings away a small quantity of cerumen, without relieving the deafness, which in these cases has commonly been of long duration and high degree. An examination now shows the meatus to be filled with a tough adhesive substance of lighter color than ordinary cerumen. The continued use of the syringe is fruitless, but crumbling fragments of the partially softened mass can be removed with curette or forceps. The removal of this form of obstruction is tedious and difficult, on account of its cohesive properties and close adherence to the walls of the canal; small fragments may be detached and brought away by the use, from day to day, of the syringe, blunt probe, and forceps, and in the intervals repeated instillations of warm alkaline solutions may be made. The writer has seen several cases in which this plan of treatment had to be pursued for four or five days before the accumulation was all removed, and in every instance the auditory canal was found more or less eroded and irregularly excavated, probably from pressure of the mass.

The term laminated epithelial plug indicates the composition of the obstructing substance, which appears to be formed by the gradual accretion of epithelial laminæ, derived from the horny elements of the cutis lining the external auditory canal, the result probably of a chronic inflammatory process in this situation. A recurrence of the obstruction may be avoided by suitable treatment of existing inflammation and by the early removal of any commencing accumulation. This disease of the external auditory canal is analogous to, if not pathologically identical with, the so-called cholesteatoma of the temporal bone, which originates in the tympanic cavity and mastoid antrum in consequence of chronic desquamative inflammation of these parts, but is of course not attended with the dangers which attend such accumulations in the deeper parts.

Parasitic Inflammation.—(*Otomycosis*, *Myringomycosis Aspergillina*.)—A definite knowledge of this subject is of comparatively recent date. Isolated observations of vegetable fungi growing in the living human ear were made by Mayer in 1844 (Müller's *Archives*, p. 410); Pacini in 1851 (sopra, "Una muffa parasita [muccdo] nel condotto auditivo esterno," Firenze, p. 7); Carl Cramer in 1859 (*Vierteljahrsch. d. Naturf. Ges. in Zürich*), and by Schwartze in 1867 (*Arch. für Ohrenheilk.*, Bd. ii., Heft i.). Wreden's publication of six cases of myringomycosis (*Arch. f. Ohrenheilk.*, Bd. iii., Heft i.), followed by his monograph in 1868, drew the attention of otologists generally to this peculiar form of disease.

Since this time numerous observations of a similar kind have been made both in Europe and in America, and the existence of several species of parasitic aural fungi has been demonstrated. The fungus most commonly met with in the ear is the Aspergillus, several species of which have been described by otologists. These are the A. nigricans, A. flavus, and A. fumigatus; some doubt, however, still prevails as to whether the two latter are not merely accidental modifications of the Aspergillus glaucus. The fungus is found under the microscope to consist of four distinct elements: (1) Mycelium, a network of filaments, tubules, or rootlets; (2) the fruit stalk or hypha; (3) the fruit head or sporangium; (4) the conidia or free spores.

The mycelial filaments or tubules consist of pale, transparent, straight or curved, branching, double-contoured fibres, which are divided at irregular intervals by transverse septa; they, as well as the fruit stalks, contain a faintly granular plasma. Their diameter varies from 0.00038 to 0.005 mm. The fruit stalks are considerably thicker than the mycelium, varying in diameter from 0.009 to 0.013 mm. Their length is from 0.3 to 0.8 mm. The terminal bulbous enlargement, called the receptaculum or sporangium (the placenta of Micheli), is about 0.028 mm. in diameter, and bears upon its surface a large number of long radiating cells (sterigmata), from the free ends of which grow the round spores or conidia, the whole forming the so-called capitulum or fruit head. The spores are spheroidal, smooth or echinate, exceedingly numerous, and very small, about 0.003 mm. in diameter; their color determines that of the fruit head, and is black-brown in A. nigricans, yellow or greenish in A. flavus or A. glaucus, and grayish-black in A. fumigatus.

According to Siebenmann ("Die Fadenpilze," Wiesbaden, 1883), the distinctive features of the fruit-bearing portions of A. flavus, A. fumigatus, and A. nigricans are as follows:

A. flavus. Fruit stalk firm, colorless, somewhat roughened, increased in thickness just below the head, 0.4 cm. in length, 7 to 10 μ in diameter, fruit head loosely formed, of a golden yellow color. Sterigmata undivided, usually found only on upper half of receptaculum, conidia sulphur-yellow or brownish in color, round or oval, surface echinate.

A. fumigatus. Fruit stalk short and delicate, 5 μ in diameter, and shaped like a reversed ninepin at its free extremity; sterigmata undivided, elongated, spring only from the convex extremity of receptaculum; the latter is occasionally spheroidal, or long oval in shape. The fully formed fruit head is never globular, its color is yellow or greenish-gray, conidia round or oval, smooth, and pale.

A. niger or *nigricans.* Fruit stalk 8 mm. in length, thick and strong, of uniform width throughout, contains a somewhat granular dark-colored plasma, of a deeper shade toward the receptaculum; its diameter is about 10 to 15 μ; sterigmata 20 to 100 μ in length, of a brown color, larger toward distal extremity, where they apparently subdivide into from three to eight prolongations. Conidia blackish-brown in color, smooth or echinate, and very numerous. The fruit heads of A. glaucus are smaller and narrower than those of A. nigricans (Burnett, *Am. Jour. of Otology*, 1879). The sporangium of A. fumigatus is, according to Bezold, still smaller than these.

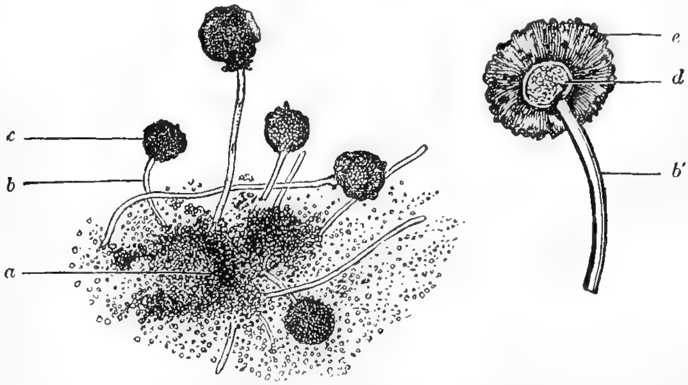


FIG. 1705.—Aspergillus Nigricans. (After Politzer.) *a*, Mycelium covered with numerous fallen spores; *b*, *b'*, hypha; *c*, sporangium, with ripe spores; *d*, receptaculum; *e*, sterigmata, with spores.

If we exclude the *Otomyces Hageni* of Hagen and Hallier, the Graphium penicilloidis of Hassenstein and Hallier, and the Penicillium of Blake, on account of their having been obtained by culture from substances of doubtful nature taken from the ear, there are still four varieties of aural fungi to be mentioned. They are: 1. *Tricotheceum roseum* of Steudener (*Arch. f. Ohrenheilk.*, Bd. v., p. 163), and *Mucor mucedo s. fuscus* of Böke (*Hungarian Med. Chirg. Press*, 1868–9, pp. 12, 16, 19), both varieties of doubtful identity. 3. Ascophora elegans of von Troeltsch ("Die Myringomycosis," p. 44). 4. *Otomyces purpureus* of Wreden (*Arch. of Ophth. and Otology*, vol. vi., No. 1, p. 87). The last-named fungus has also been once observed by Burnett (*Arch. of Otology*, vol. x., No. 4, p. 319). In Wreden's case the false membrane also contained spots of Aspergillus nigricans, and he was led to believe that the O. purpureus represented *the ascomycete of the Aspergillus nigricans, that is, the highest form of the specific aural fungus.* Burnett, however, found no evidences of such relationship in his case, and regards the *O. purpureus* as a species *sui generis.*

All the conditions requisite for the growth of aural fungi are not yet fully understood, but since attempts to cultivate the growth in the healthy human ear have uniformly failed, it seems probable that the presence of certain pathological changes, attended with undue moisture or a softened and loosened condition of the epithelial lining of the meatus, are essential to the development and growth of the fungus in the ear. The age and hygienic surroundings of the patient, the climate, and the season of the year are not without influence. The Russians, living as they do in artificially heated and badly ventilated dwellings during the long winter season of that climate, seem especially liable to otomycosis. The poorer classes, who live in damp apartments, are said to be more frequently affected than those whose circumstances are more fortunate. If this be true, the comparative immunity of the English people, notwithstanding the dampness of their climate and the large pauper population, is somewhat remarkable. In Germany and the United States the disease is by no means rare, but in the province of Quebec the writer has met with only one example of aural fungus among thirty-five hundred patients. This case was one of A. nigricans; it occurred in a youth fifteen years of age, the son of a wealthy merchant, and is all the more remarkable because young people are seldom affected in this way. This patient came under notice again about a year later on account of a slight diffuse otitis externa without any recurrence of the fungus.

The disease is prone to occur in ears that are already diseased, but is seldom or never found in the presence of an active purulent otitis. Substances which readily undergo decomposition, such as fats and oils, instilled into the ear, are said to favor the development of Aspergillus. The presence of normal ear wax is unfavorable to its development. There can be little doubt that this affection was formerly often mistaken for impacted cerumen, or for ordinary otitis externa diffusa. The fungus usually originates in the deeper portions of the auditory canal and upon the membrana tympani; hence the name myringomycosis. The irritation which it causes may induce ulceration of the membrana tympani and an extension of the fungus to the tympanic cavity; but when the new growth is met with in this situation an exhausted suppuration, with perforation of the membrane, has usually preceded the development of the fungus.

Symptoms.—Growths of fungus in the external meatus and tympanic cavity may exist for a considerable time without exciting any troublesome irritation; according to Bezold this is especially true of the A. fumigatus. Sooner or later, however, the form of inflammation known as otitis externa parasitica sets in. This results from the fungus having penetrated the epidermis and reached the living tissues (Politzer), or in consequence of irritant qualities of the fermentation products to which the growing fungus gives rise (Siebenmann).

The subjective phenomena of parasitic otitis are itching of the meatus, lancinating pains, and a feeling of fulness in the ear; tinnitus is usually present, vertigo rarely so; the impairment of hearing is often considerable. On examination, the walls of the meatus and the membrana tympani are seen to be partly or completely hidden by a membranous substance of a dull whitish, yellowish, or blackish color. In Otomyces purpureus, the meatus has been found occluded with a red substance resembling blood clot, and in A. flavus it is spoken of as containing a yellow, dust-like substance, like pollen dust. There is often a watery discharge from the ear. When the ear is syringed, shreds of membrane resembling wet paper may be removed; sometimes the aid of forceps is required. The fruit heads of the fungus are visible to the naked eye as black or yellow dots on the surface of the false membrane; the microscope will readily show their peculiarities of structure. When the fungus is removed, the auditory canal is found to be more or less reddened and tender; if no other measures are resorted to, the growth may be reproduced in a few hours.

The *prognosis* is favorable in all varieties of otitis externa parasitica, as there is no difficulty in destroying the growth by the use of suitable remedies and thus effecting a speedy cure. Fresh attacks may occur if the surroundings of the patient remain the same.

Treatment.—Of the many remedies recommended for the destruction of the fungus, alcohol is probably the best. The ordinary spirits of wine may be used. After removal of the casts with a syringe and warm water, the meatus may be filled with warm spirit, which should be allowed to remain in the ear for ten or fifteen minutes. This may be repeated twice daily for several days. The spirit may be diluted if it causes pain, and gradually increased in strength if necessary. Three or four days of this treatment will suffice to effect a cure. To prevent relapses, Politzer advises the occasional use of the spirit for at least a year; this precaution, however, will seldom be necessary.

Many other remedies have been found sufficiently effective; repeated syringing with warm water would probably suffice, though not so rapidly as when combined with the use of some parasiticide. Wreden extols the use of chlorinated lime (0.07 to 0.15 in 35.0 aq. dest.), Blake and Burnett, the hyposulphite of soda (0.2 in 300). Boracic acid in powder, alone or with an equal quantity of oxide of zinc (Theobald), or in alcoholic solution (1 to 20); permanganate of potassium in one or two per cent. solution (v. Troeltsch *et al.*); carbolic acid in glycerin (3 in 100, Lucæ); salicylic acid in alcoholic solution, two per cent. (Bezold); bichloride of mercury in water (1 to 500), and various other remedies, are mentioned by different observers. Painting the meatus with strong solutions of nitrate of silver is found beneficial if inflammation persists after removal of the fungus (Roosa). If the affection be complicated with middle-ear disease, this too will require appropriate treatment.

Pityriasis alba of the external meatus has been described by Ladreit Lacharrière (*Annales des Maux de l'Oreille,* 1875) as a rare form of mycosis, for which the treatment is extraction of the stiffest hairs and painting the meatus with a one-per-cent. solution of corrosive sublimate.

DIFFUSE INFLAMMATION (*Otitis Externa Diffusa*).—Diffuse inflammation of the external auditory meatus is either acute or chronic, primary or consecutive. The consecutive form occurs in connection with inflammatory affections of the middle ear, and is subordinate to the deeper-seated disease. As a primary affection, diffuse inflammation is rarely of idiopathic origin, but may usually be traced to the instillation of irritating substances, or to mechanical and traumatic causes. The lining of the osseous section of the canal is the part chiefly affected, though the membrana tympani and the outer portion of the meatus may become involved as a complication of, and consecutive to, chronic purulent otitis media. It is by no means uncommon, especially in unhealthy, badly nourished children.

Symptoms.—The acute form of the disease begins with itching sensations in the ear, followed by a feeling of fulness and heat. Pain of moderate or intense severity occurs early, and is always increased by pressure on the ear and by movements of the jaw. Tinnitus and giddiness are sometimes complained of. The impairment of hearing is slight, except when the membrana tympani is considerably swollen and the auditory canal contains a sufficient quantity of secretion and exfoliated epithelium to obstruct its lumen.

The objective signs are a whitish exudation lining the walls of the canal, and consisting mostly of exfoliated epithelium, often of a pasty consistence from admixture with viscid secretion; sometimes it consists of a continuous pouch-like membrane. The real condition of the auditory canal can be seen only after removal of this abundant exfoliated material. After syringing, or careful cleaning with the ordinary cotton-wrapped applicators, the meatus is found to be more or less narrowed from swelling, especially of its deeper parts, and at the same time reddened and sensitive. The line of demarcation between the meatus and membrana tympani, as well as the usual anatomical features of the latter, may be obliterated by the swelling and uniform redness of these parts; occasionally the meatus is so contracted by diffuse swelling that a view of the deeper parts is not obtainable. If the drum membrane is found to be fairly normal, it is fair to assume that the disease is confined to the auditory canal. The writer once observed a case of diffuse otitis externa, occurring in a profoundly hysterical subject, which was characterized by attacks of intense pain followed in a few hours by the formation of large blebs containing serous exudation of a pale yellow color; in this way the entire epidermis of the meatus, and probably of the membrana tympani, was several times thrown off, leaving a moist, not swollen, but reddened and intensely sensitive surface, which speedily became covered after each attack with normal epidermis. With the cessation of the recurring inflammation, complete anæsthesia of the meatus and membrana tympani supervened; there was also sudden and total deafness which lasted for several months and was obviously of a functional character.

The acute form of otitis externa diffusa usually subsides under proper treatment in the course of a few days; in less favorable cases there may be relapses of the inflammation, ulceration of the meatus or membrana tympani, and the formation of polypoid growths.

In chronic diffuse inflammation there is little or no pain, but more or less itchiness with scanty discharge; its duration will depend largely upon the presence or absence of complications, such as purulent disease of the middle ear. If the discharge is distinctly of a fœtid character, careful examination should be made for other evidences of chronic mastoid disease or of bone caries involving the ossicles or tympanic walls. Suspicious-looking flakes or casts should be examined for fungous growths.

The possible consecutive nature of the disease should always be held in view, and the diagnosis not considered complete until proper steps have been taken to prove the non-existence of deeper-seated disease.

The *prognosis* of uncomplicated otitis externa is favorable in all its forms.

Treatment.—While the acute symptoms last, leeches, anodynes, scarification of the inflamed parts, and warm-water irrigation are in order. If the disease be of traumatic origin, continuous applications of cold compresses, or of Leiter's coil, to the region of the ear are serviceable. Leeches when applied should be placed in front of the tragus; an artificial leech specially adapted for abstraction of blood in the vicinity of the ear may be used with advantage and is free from the objectionable qualities of the Hirudo officinalis. In this affection it is claimed that the best results from the use of the artificial leech are obtained when it is applied to the mastoid region (Dench). Scarifications are to be made only in the early stage, before exudation has occurred. The incisions should be three-fourths of an inch long in the walls of the canal (Gruber). For warm-water irrigation, the fountain syringe, or some form of continuous aural douche, may be employed. Anodyne instillations of solutions of morphine or atropine may be used; in childhood the latter cannot be used with too much caution, especially if the drum membrane is perforated.

Poultices, if used at all, should not be applied for more than two or three hours consecutively, not only on account of their tendency to promote the formation of polypoid growths, but because in painful affections of the ears they may—when used to an excess, as is often done by the laity—prove to be veritable incubators for the nurture of innumerable disease germs. In this way they may, in effect, aggravate the disease which they are designed to cure.

In all chronic cases, repeated cleansing of the ear with some mild antiseptic irrigation is indispensable. Insufflations of boric acid powder, after the canal has been cleansed, often act like a charm, and may be employed even in acute cases, when discharge has set in. This may be repeated whenever the powder has become moist. Strong solutions of nitrate of silver are often very useful, but must be avoided so long as there is pain. In some chronic cases the insertion of a plug of cotton wool, smeared with diachylon ointment, effects a speedy cure (Buck, Roosa). In these cases the disease has probably been of an eczematous character.

ACUTE CIRCUMSCRIBED INFLAMMATION (*Follicular Inflammation, Furuncles, Boils, Otitis Externa Circumscripta*).—This form of inflammation seems to have a special predilection for the external auditory canal, having its seat almost exclusively in the cartilaginous portion. The disease is quite common in adults, rare in childhood, and seldom or never met with in infancy. It is said to occur with special frequency in spring and autumn, sometimes as an epidemic, and sometimes associated with a more general furunculosis. Anæmia, gout, disorders of menstruation, diabetes mellitus, and change of life are said to predispose to auditory furuncles. Strong and otherwise healthy persons are by no means exempt from it, but debility induced by an unhealthy mode of life, or by living in badly ventilated houses, seems to exert a predisposing influence.

As local causes may be mentioned: chronic discharges from the ear; chronic eczema of the meatus; mechanical irritation, such as may be caused by the presence of foreign bodies; frequent syringing; scratching the meatus with hard instruments, such as hairpins and toothpicks; irritating medicinal applications, and the use of alum lotions. The sebaceous and ceruminous follicles are probably the starting-point of the inflammation; occasionally it originates more deeply, in the perichondrium, or in the substance of the cartilage (Buck).

The pus of aural furuncles has been found loaded with micrococci (Löwenberg), and it is not unreasonable to suppose that furuncular inflammation may originate from these having found their way into the glandular follicles from the air, or from the water used in syringing; in any case, moisture would favor their rapid development, and this may be the reason that syringing the ear is apt to excite furuncular inflammation. Although slight local lesions, such as would favor the introduction of pus-producing disease germs, commonly initiate otitis externa circumscripta, the affection cannot always be shown to originate in this way. Trophic disturbances of the parts, possibly of a reflex nature, are alleged to be the active causative agents in this case.

Symptoms.—The first perverted sensation is a feeling of fulness and discomfort, soon followed by slight lancinating pains or by itchiness. If the inflammation is superficially situated, the pain is usually slight; if it is deep-seated, the pain may be very severe, of a tearing or beating character, and radiating to other parts of the head and neck. It is intensified by pressure, by traction of the auricle, and by movements of the jaw. Hardness of hearing, a feeling of fulness, and tinnitus are complained of in some instances, especially when the meatus is much obstructed by the swelling, which always involves the cartilaginous portion of the meatus, and is most marked in that part of the canal which happens to be the seat of the inflammatory focus. According to Dench the inferior, posterior, and superior walls are more frequently affected than is the anterior. Infiltration and induration of the adjacent lymphatic glands are by no means infrequent changes, and occasionally the parotid becomes involved. A large and deep furuncular abscess in the posterior wall may be mistaken for mastoid disease, but the absence of tenderness, except when pressure is so directed as to move the wall of the meatus, differentiates the two conditions. Sometimes the tissues behind or in front of the ear are swollen and the skin is reddened.

Superficial furuncles appear more or less red from the outset; when they are deep-seated, the redness is not present until the abscess approaches the surface. Febrile symptoms may be present in the severer cases. Tenderness over the inflamed centre is a constant symptom; several furuncles may occur at the same time, or follow each other in rapid succession. Repeated attacks are not uncommon.

Resolution of the inflammation without suppuration seldom occurs. If the disease is left to nature, rupture of the abscess will take place sooner or later, often not for many days if the disease is deep-seated. After rupture of the abscess the swelling and pain quickly subside. Polypoid granulations requiring removal may develop from the point of rupture. The locality of the swelling and the tenderness, together with the absence of symptoms indicative of deep-seated disease, render the diagnosis a matter of no difficulty. The presence of an exostosis covered with inflamed cutis, or bulging of the posterior wall of the meatus from mastoid disease, might be mistaken for furuncular inflammation, but neither of these conditions could deceive a careful observer. Inflammation of the deeper portions of the meatus in which glandular elements are wanting, is probably not furuncular.

Treatment.—Measures must be employed to allay pain, to shorten the duration of the disease, and to prevent relapses. If the case is seen sufficiently early an effort may be made to abort the attack. Some aurists recommend local depletion by leeching or by means of the artificial leech; others have no confidence in this procedure, but rely upon the topical application of strong antiseptics such as a saturated solution of boric acid in alcohol frequently applied, or alcoholic solutions of menthol, carbolic acid, creosote, eucalyptol, etc., these latter being sedative in their action as well as antiseptic. They may be applied in solutions varying in strength from five to ten per cent., on pledgets of cotton wool, and they have the further advantage of tending to prevent the formation of fresh foci of inflammation. Of all these menthol is probably the best.

If a fair trial of such measures does not afford relief, the local application of some form of dry heat will have a soothing effect, and, by softening the tissues, will assist nature in bringing the suppurating area nearer the surface; at the same time syringing the ear every few hours with some warm antiseptic solution is recommended. Most otologists are agreed in recommending an early incision of the swollen parts at the point of greatest tenderness, which may be ascertained by the use of a cotton-guarded probe. The incision should be sufficiently deep and long thoroughly to divide and relieve tension of the inflamed area; a short strong and very sharp bistoury should be used. General anæsthesia is hardly necessary, but the writer can from his own experience confidently recommend the administration of ether up to the point of producing the first stage of anæsthesia, the patient sitting upright in a chair and taking the anæsthetic himself. When the proper moment arrives, an instantaneous incision can be made without inflicting pain. After the incision has been made syringing with warm bichloride, 1 to 6,000 or 8,000, is in order. This cleansing may be repeated several times daily and supplemented by the use of a dilute solution of boric acid in alcohol, to be instilled after syringing, until the discharge ceases. Should granulations or polypoid excrescences spring from the wound, their removal with the cold snare, by curetting, or by caustic applications will be indicated.

The sulphide of calcium, Fowler's solution of arsenic, iodide of potassium, and other remedies given internally, have been recommended by several otologists of repute, but their actual value has not been sufficiently established to warrant more than a passing mention. Anæmia, constipation, etc., must be corrected by suitable therapeutic measures. Change of air may be advisable if the disease is protracted by repeated formation of furuncles, and if the patient's sanitary surroundings are obviously insalubrious. Errors of diet and all the recognized exciting causes should, as far as possible, be avoided.

A mild form of membranous otitis externa is seen as a rare affection, the membrane being detachable without exposing a bleeding or ulcerated surface, and belonging to the type of so-called croupous exudation.

ECZEMA.—To avoid repetition it has been thought best to consider the subject of eczema of the auricle and of the external meatus in the same section, and, for the same reason, the sections relating to pathology, causation, and general principles of treatment will be omitted; the reader being referred, for information in regard to these subjects, to the general article on *Eczema.* We have, therefore, to consider the subject only from the standpoint of the otologist, which means an attention to certain details, chiefly in the matter of local signs, diagnosis, and treatment, not likely to be found in the text books on dermatology or in the article above mentioned.

This form of dermatitis may, and as a matter of fact often does, invade the auricle and meatus as a part of a more extensive affection, and the patient will then, as a rule, not come under the observation of the otologist at all. There are, however, a considerable number of cases in which the aural disturbances appear to be the more important, and the subjects thereof naturally seek the advice of an otologist, if such can conveniently be obtained, before going elsewhere. It is then to this local manifestation of eczema that we purpose calling the reader's attention. As in eczema of other parts, the morbid condition of the integument of the meatus, auricle, and adjacent parts presents itself under two forms, acute and chronic.

Acute Eczema of the Auricle.—In typical cases of this disease the eruption is seldom confined strictly to the integument covering this structure, but involves to some extent that of the meatus and also the adjacent hairy scalp; nevertheless the red, swollen, and inflamed auricle is the chief feature of the disease and becomes the source of no little distress and anxiety to the patient. Here, as in eczema generally, the predisposing cause seems to be some constitutional diathesis or fault in nutrition, as gout, rheumatism, or scrofulosis, of which there may be no signs until some further disturbing influence is brought into play, such as disorders of digestion, unsuitable articles of diet, perverted habits of life, or anything which interferes with the proper balance between assimilation of food and excretion. This will account for most of the apparently spontaneous attacks of eczema; but there are many cases which seem to come on as the result of some local irritation, reflex, mechanical, or thermic in character, or as a secondary manifestation, following some ichorous discharge from the middle ear and meatus. In these, also, some of the above-mentioned underlying causes doubtless play a part; children and members of certain religious communities whose ears are kept closely hooded in warm weather are particularly liable to eczema about the auricle, which often appears to commence as an intertrigo between this part and the skin behind it.

An acute eczema of the auricle begins with a sensation of heat and tension (which, later on, gives place to an intense pruritus); thus there is much swelling and redness. The ear now appears to project unduly from the side of the head, and the clinical picture strongly resembles that of erysipelas, but lacks the peculiar œdema, the mode of extension, and the severe constitutional disturbance of this disease; the last mentioned being absent or comparatively slight in acute eczema.

An exudation of fluid occurs beneath the epidermis, and this manifests itself in one of two ways: either there is a multitude of fine vesicles or else the superficial epithelium may simply be cast off by the exudation, without distinct vesiculation. In either case there is an exudation, from the surface, of a copious yellowish or sanguinolent, sticky fluid, and the skin appears raw and inflamed. Pus also now appears upon the surface, and the discharge, in drying, forms crusts or scabs over the affected part. If these are removed, a raw, sometimes bleeding, surface will be found underneath.

After this stage has been reached, if the disease attacks the hairy scalp, as it is especially apt to do in strumous children, the lymphatics become affected, as shown by enlargement of cervical glands. The skin lining the auditory canal may be involved to such an extent that tinnitus and partial deafness occur. If left untreated, the disease readily becomes chronic, with thickening and induration of the deeper layers of the skin.

If a local irritation, such as chronic discharge from the ear, is the chief factor in bringing on an attack, it often remains unilateral; but when the affection is due solely to constitutional causes both ears are generally affected at the same time. When an acute eczema is limited to the auricle and canal, it is scarcely possible to differentiate it from a diffuse otitis externa due to any other cause.

Chronic eczema is not necessarily or indeed often traceable to an acute attack, and is by far the more common form. It occurs as an extension from the hairy scalp, or as the result of some local irritation, or from a constitutional tendency which may give rise to a localized eczema at any part of the general integument. It often remains localized at some particular part of the ear for an indefinite period. The localities most often affected are: the meatus or the lobule, as a result of chronic otorrhœa or from wearing faulty earrings; the posterior attachment of the auricle to the head, especially in children; the fossa of the helix; the antihelix; the concha; and, lastly, the entire auricle. A slight scaly irritation of the outer half of the external auditory canal, attended with pruritus, represents a very common and mild form of the disease. This condition in a more pronounced form is often met with in women suffering from the debility which belongs to various pelvic disorders and their attendant digestive disturbances.

Thickening of the entire integument is characteristic of chronic eczema; it sometimes amounts to a veritable hypertrophy of the affected part, and may occlude the external meatus so much as to interfere with audition. The skin usually feels hard, leathery, and thick. Its appearance is not always the same, but varies somewhat from time to time even in the same case. A dull pinkish color is often present; sometimes the skin is smooth and glossy, as if it were tightly stretched, or, if the epithelium is cast off rapidly, it will be covered with whitish scales and will present a more or less rough surface. Efforts to relieve the pruritus may lead to abrasions and perhaps bleeding; hence blood-stained crusts or scabs are often seen, and a temporary increase of the local inflammation may ensue from the same cause.

Pruritus is a constant symptom of chronic eczema and is sometimes exceedingly annoying. Wherever the skin is much thickened, the surface is apt to present fissures extending into the corium. These are particularly noticeable about the entrance of the auditory canal wherever the meatus has long been the seat of a chronic eczema.

Treatment.—In both varieties of eczema the constitutional aspect of the disease should first be considered, and suitable treatment for this must be adopted. Habitual errors of diet, etc., must be corrected. The internal administration of various alkaline and laxative remedies—such as Rochelle salts, the neutral tartrate of potash, bicarbonate, acetate or citrate of sodium, in rather large doses—materially aids local treatment in bringing about a cure. Local exciting causes, if present, must of course be eliminated.

In the acute form the subjective symptoms require special measures for their relief. Cold evaporating lotions tend to allay the heat and itching, often so distressing to the patient. Pledgets of lint laid over the part and kept moist with a solution containing liquor plumbi acetatis 3 parts, glycerin 6 parts, and water 100 parts, will be found to answer the purpose very well. One per cent. of bismuth subnitrate and a small quantity of morphine may be added to this to increase its soothing effect. In the presence of a profuse discharge from the inflamed surface a drying powder, containing combinations of starch, lycopodium, oxide of zinc, stearate of zinc, bismuth, etc., in varied proportions, may be found preferable to the moist dressing; but if the burning sensation in the skin is intense, some form of ointment is indicated. One or more of the four last-mentioned drugs (with or without boric acid, or morphine), combined with vaseline, make an excellent dressing. The unguentum diachyli or an ointment containing two per cent. of creolin, smeared on pieces of soft rag, may be applied constantly.

It is not at any time desirable to irritate the inflamed surface mechanically; hence, when crusts have formed, they must be softened with olive oil or vaseline until they can easily be removed, after which the surface should be treated with some soothing protective powder, or with one of the ointments already mentioned. Washing the affected parts with water is always to be avoided, but cleansing occasionally with a solution of subacetate of lead may be practised with benefit.

Chronic eczema of the ear is apt to run a protracted course, even under the most favorable circumstances, and especially so if suitable treatment be not persistently carried on, or if it be omitted too soon.

The local applications employed will require to be varied from time to time in most chronic cases. In a general way applications of an astringent and stimulating character are to be employed, but in the presence of an acute exacerbation it may be necessary to resort to more soothing remedies. A light covering to protect the auricle may often be used with advantage, but not to the extent of causing undue heat and moisture of the skin, a circumstance which, as already mentioned, may bring on eczema in certain persons.

There are many formulæ for mild stimulating and astringent ointments, such as diachylon ointment; oil of cade in vaseline, three per cent.; benzoated lard, with or without oxide of zinc or bismuth; boric acid in vaseline, four per cent., etc. All of these act beneficially, in part at least, by excluding the air from the inflamed skin. Olive oil or vaseline should be used freely to soften scales and crusts, so that they can be wiped away; some warm emollient poultice is a useful adjuvant to these, if the softening effect of the oil is insufficient. When the skin is greatly thickened, indurated, and covered with dry, exfoliating epidermis, stronger stimulation is indicated. Under these circumstances one of the following ointments may advantageously be employed: an ointment containing tar or ammonio-chloride of mercury; a mixture of equal portions of ung. picis liq. and zinc ointment; simple benzoinated lard, or the latter with four or five per cent. of the ammonio-chloride; and, finally, ichthyol and benzoinated lard. Acetum cantharidis, which is a still stronger stimulant, has been found to act better than any other remedy in allaying the itching and reducing the brawny infiltration of the skin. This effect is due to the free serous transudation which it induces. It may be painted over the affected part with a cotton-wool swab once every twenty-four hours, until the proper effect is obtained—that is, exfoliation of all thickened epidermis and softening of the skin, which then becomes covered with a thinner and more normal epithelium. Should the reaction be excessive, some soothing ointment will allay all discomfort in a few hours. The process may be repeated every few days until all thickening has disappeared. Many authorities highly recommend nitrate of silver—in solutions of from two to four per cent. or even greater strength—as a local application in chronic eczema. Painted over the surface after all scales have been removed, it stimulates the epithelium to a more healthy growth, especially after the thickening of the skin has been reduced by the use of the remedies already mentioned. For the relief of fissures in the skin of the meatus the writer has found repeated painting with a strong (ten to twenty per cent.) solution of silver nitrate most efficient. Practitioners who are in the habit of prescribing arsenic in all cases of chronic eczema will do well to remember that this treatment has not found much favor with dermatologists of the present time; its effects, although sometimes favorable, have on the other hand often been found decidedly injurious.

True Diphtheritic Otitis Externa does sometimes occur, but very rarely, and then almost always as a complication of scarlatinous diphtheritis of the throat and middle ear (Politzer). Primary diphtheritis of the meatus has been observed during epidemics of diphtheritis; but in these few instances there already existed an inflammation or excoriation of the meatus, and it was in this favorable soil that the accidental infection occurred. This primary form is said not to be attended with constitutional disturbance and readily yields to treatment.

A false membrane of a dirty white color and firmly adherent to the walls of the meatus is characteristic of diphtheritic otitis externa. When the membrane is forcibly removed, the exposed parts are found tender to the touch, excoriated, ulcerated, and bleeding. Severe pain, a feeling of fulness, tinnitus, and deafness only occur in the primary form of this disease; when it is associated with diphtheritis of the throat and middle ear, there is little or no pain, but there may be anæsthesia of the parts around the ear (Wreden, Wendt, Blau). Primary diphtheritic otitis externa usually terminates in recovery without injury to the ear. The consecutive form (in reality a diffuse otitis externa) is apt to result in destructive ulceration of the membrana tympani, exfoliation of the ossicles, and more or less extensive caries of the temporal bone. Such destructive changes depend upon the severity of the original disease—diphtheritic inflammation of the fauces, or the angina of scarlatina with tympanic complications.

The *treatment* of diphtheritic otitis externa should be antiseptic. Lime-water instillation, followed by syringing with a solution of boric acid, will favor separation of the membrane (Burkhardt-Merian). After syringing, the meatus may be filled with powdered boric acid. Carbolic glycerin (1 to 15), carbolic spirit (1 to 20), or a solution of boric acid in spirit (1 to 20), may be painted over the affected parts if the membrane, after being once detached, tends to form again. Forcible detachment of the membrane is injurious and likely to be followed by fresh infection of the denuded surface and an aggravation of the local condition. The treatment with antitoxin and the employment of constitutional remedies are indicated in this as in other forms of diphtheria.

Syphilitic Affections of the Meatus are discussed in one of the later articles of this series, and the reader is therefore referred to this for information upon the subject.

Exostoses and Hyperostoses of the external auditory canal are not of infrequent occurrence. They are congenital or acquired, and may be single or multiple, spongy or eburnated, pedunculated or with broad base. Their favorite situations are at the outer portion of the osseous meatus, or at its inner extremity, close to the membrana tympani. Occasionally they entirely close the lumen of the canal, but only in this event, or when the already narrowed meatus becomes blocked with secretion, do they cause much disturbance of hearing. This is the more likely to occur because the presence of these tumors favors inflammation of the cutaneous lining of the meatus. Exostoses are often bilateral, and they are much more frequent in the male than in the female sex. The causes of acquired exostoses have not been determined with certainty. Rheumatism, arthritis, and syphilis are spoken of as constitutional causes, but these tumors are often hereditary and unassociated with any of these diseases. Among the aborigines of America and the natives of the Sandwich Islands, they seem to occur with special frequency; in the latter, excessive indulgence in sea bathing, with the consequent irritation of the auditory canals by salt water, is alleged to be the cause of this development. Local processes involving chronic hyperæmia of the auditory canal seem to predispose to overgrowth of the adjacent bone, sometimes in the form of diffuse hyperostoses but more often as circumscribed outgrowths or exostoses. When they coexist with chronic suppuration of the middle ear, their presence forms an additional source of danger by favoring retention of pus. Fig. 1706 gives a good idea of the appearance presented by multiple exostoses. They usually appear as white or yellowish, smooth prominences, and when examined with a probe are found to be exceedingly firm to the touch. This feature serves to distinguish them from all other pathological formations in the meatus, even when the skin covering them is red and inflamed.

Small exostoses may last a lifetime without detriment to the subject, but larger osseous growths are apt to give trouble by favoring the accumulation of cerumen, epidermis, etc.

Treatment.—Medication, local or general, with a view to procuring absorption, is useless. When the exostoses are of small size and present no evidences of irritation, they should not be interfered with. If chronic suppurative disease of the tympanum is present it should, if possible, be healed; if this is impracticable, the auditory canal must be kept scrupulously clean. An accumula-

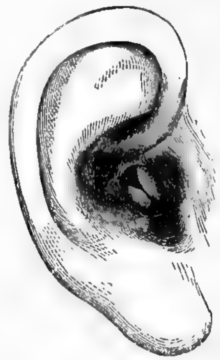


Fig. 1706.—Two Exostoses of the External Auditory Canal, in Contact Internally. (After Toynbee.)

tion of secretion beyond the growths may, with care, be removed, even through a small aperture. The offending substance may, if necessary, first be softened by injecting a few drops of warm solution of carbonate of soda (1 to 20) through a suitable cannula, the point of which is pushed into the aperture; then, on the following day, a free injection of warm water through the same instrument will probably bring the accumulation away. When the narrowing of the canal is too great to admit of such cleansing measures, and there are great deafness and deep-seated pain, indicating pressure from retained secretion, surgical removal of the exostosis may become imperative, or a counter-opening, extending down to the antrum, may be established in the mastoid process. The operative procedure to be chosen will depend chiefly on the particular characters of the case. If the growth is obviously pedunculate and can be surrounded by a suitable steel snare wire, it may be removed in this way, or the peduncle may be broken by a few taps with chisel and mallet. As a rule, however, growths of this kind requiring operative interference are of a more sessile kind and must be chiselled away piecemeal or drilled through at their bases and then detached with chisel and mallet. Formerly, operations of this kind were done through the external meatus, but the difficulties encountered were such as to make some easier method desirable. This has been attained by first detaching the auricle from behind, throwing it forward, and so exposing the comparatively short bony canal—a procedure which has been found greatly to facilitate removal of the growth, especially if it springs from the inner portion of the canal.

Absence of the Meatus.—Occasionally the meatus is found terminating as a smooth, cutaneous cul-de-sac, without any appearance of a tympanic membrane; the canal, under these circumstances, being smooth, pale, and shorter than normal. This condition results from ulcerative inflammation of the meatus, with immediate contact and union of its walls, or the union may take place through the intervention of granulation tissue. The atresia may be formed by osseous or fibrous tissue, or it may consist of only a thin septum. If the obstructing tissue does not consist of bone, the fundus of the cul-de-sac will be found to be yielding and elastic. If, under these circumstances, bone conduction shows a normal condition of the internal ear, the septum may be divided or partially excised, and a permanent opening secured by the introduction of leaden pegs, or, better still, a smooth glass plug conical in shape may be retained in the canal until healing has taken place. Politzer relates a case of this kind in which he obtained great and permanent improvement in the hearing. The writer, too, has had excellent results through the use of a perfectly smooth glass cone instead of the leaden plug.

Polypi.—The development of pedunculated connective-tissue growths in the meatus is a common sequence of neglected chronic suppuration of the middle ear. Those which grow from some part of the tympanic mucous membrane will receive due consideration in the article which treats of the latter subject. Polypi may also develop from the lining of the meatus, their point of attachment commonly being the posterior or superior wall, near the membrana tympani, while only rarely do they originate from a more external part of the auditory canal. In the case of those growths which spring from the meatus, it is said that they often result from prolonged and injudicious poulticing.

Aural polypi are usually single; several may, however, grow simultaneously in one ear. Their surface is smooth or finely lobulated, and they are always covered with epithelium. They are sometimes large enough to fill the meatus, and they may even project for a short distance beyond the external orifice; others, again, do not exceed the size of a pea and present no external evidence of their presence. When they are small but yet large enough to be moulded by the meatus, their shape is globular, pear-shaped, or elongated. Those which project beyond the external meatus are of a pale color and have a surface covered with epithelium not unlike that of the adjacent integument.

The diagnosis of polypi presents no difficulties. Simple inspection will suffice to determine their presence. Malignant new formations, springing from the same parts, may possibly lead to an erroneous diagnosis. Careful exploration of the meatus with a blunt probe will generally enable the surgeon to determine the point of attachment of the polypus. According to Politzer, pale-red or pearl-gray polypi, with a smooth or moderately rough surface, spring usually from the meatus; while the sodden, red, vascular, raspberry-shaped growths with villiform papillated surfaces, most frequently arise in the tympanic cavity.

The *prognosis* is generally favorable, especially in the case of polypi which spring from the meatus, their thorough eradication being less difficult than when the growth originates in the less accessible tympanum. Large polypi, of course, always act as mechanical impediments to hearing, and their removal may be followed by great improvement in the hearing power; the prognosis, however, must be guarded in this respect, even when there is reason to believe that the condition of the internal ear is normal, since the physical conditions in the middle ear (subject as it has been to the pathological changes incident to a long period of chronic suppurative inflammation) may render a restoration of the hearing impossible.

Treatment.—Removal of polypoid growths is always advisable; it may be accomplished in various ways. When the fact can be established that the growth springs from the walls of the meatus, its extraction by means of Wilde's or Blake's snare may be undertaken. The loop of the snare should be tightened around the pedicle of the growth, close to its insertion, and the operation completed by traction; or, if a moderate amount of traction will not suffice, ligature of the polypus may be effected by rotating the instrument on its long axis until a greater resistance is felt; whereupon the wire is cut loose from the cross bar and the instrument removed, leaving the twisted wire loop around the pedicle. This causes strangulation and death of the growth.

If there is a probability that the growth springs from the membrana tympani or from the tympanic cavity, it should be snared off as deeply as possible, traction not being admissible on account of the damage that might accrue to the drum membrane. Politzer's annular knife is also a valuable instrument for the excision of polypi. Small pedunculated growths may sometimes be crushed, or removed with suitable forceps, or with one of Buck's loop curettes. In most cases, after removal of the mass, the root will require to be touched at intervals of three or four days with chromic acid, applied very carefully, under good illumination, by means of a cotton-tipped probe.

The galvano-cautery may be used with advantage for the removal of large, firmly attached fibroid polypi, and also for cauterizing granulations and the remnants of polypi. Its use is said to be followed by less inflammatory reaction than is observed after the employment of caustics.

As the subject of benign growths in the external auditory canal is fully discussed by the writer of the article on chronic suppurative inflammation of the middle ear, and inasmuch as there are to be special articles devoted to malignant new growths and to injuries of the ear respectively, the present writer considers himself at liberty to omit all further mention of these subjects in this article.

Frank Buller.

EAR DISEASES: ALTERATIONS IN THE TYMPANIC MEMBRANE AND ADJACENT BONY WALLS DUE TO FORMER DISEASE.—Inasmuch as the active or current changes of the drumhead and adjacent walls incident to the various diseases are to be dealt with in the more clinical articles, it is here designed to present the sequent and more persistent changes and, in any overlapping of fields, to take the standpoint of the morbid anatomy and the general processes producing them. My topic does not deal with the drum membrane alone, but also with the related structures; for clinical otology is accepting in slowly increasing degree the teachings of aural anatomy which we owe to Leidy, and is recognizing that the tympanum includes always the antrum and attic as well as the lower cavity, and hence that its outer bony wall must be considered with the membranous. And just as modern anatomy has ceased to lay stress upon those details of structure, like the bony labyrinth, which have a merely picturesque interest but are without developmental or physiological importance, so as pathologists we should slight mere morbid changes, however demonstrable as results, in favor of the study of the perverted processes which they indicate and which it is our clinical duty to combat.

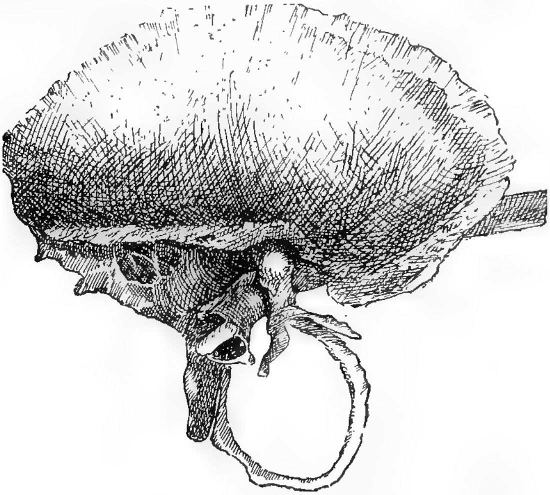


FIG. 1707.—Inner Aspect of Squama in its Relation to the Annulus and Ossicles. The scute is partly hidden by the incus and malleus head, but the posterior and descending portions are well shown, with the tegmen roofing in both antrum and attic.

The outer wall (more strictly the lower, as it looks more down than out) of the tympanum consists of the tense or vibrating drumhead, the flaccid membrane above the folds that stretch in both a backward and a forward direction from the short process, and the bony wall (*pars ossea*, Walb) that separates the attic and antrum from the auditory meatus. This last is in the adult an undefined part of the canal wall; but in the infant it is a triangular process of the squama (the "scute" of Leidy) which can be readily detached from the petro-mastoid to uncover these upper tympanic cavities (Fig. 1707). From this plate all of the upper and most of the back wall of the canal develops, just as the remainder of the wall is the outgrowth of the tympanic bone or annulus. Hence the region of election for opening the antrum, and the *spina supra meatum* which marks it in the adult, are located, at least in infancy, in the squamosal and not in the true mastoid portion of the temporal bone. But it is only the innermost part, corresponding with the undeveloped "scute," which remains a bounding wall of the tympanic spaces.

Something of the same sort may also be said of the original annulus, since the bottom of the tympanum proper almost undermines it, forming a "cellar" (Kretschmann) below. The usual lack, in this region, of septal folds interfering with drainage makes it far less liable to special involvement than the antrum and attic; although it is not infrequently the seat of persistent caries, and its close relation to the bulb of the jugular and the lower curve of the carotid can render such a caries serious.

As the triangular light spot should constitute the most conspicuous feature of the normal drumhead (Plate XXV., Figs. 1 and 2), so its alterations are among those most easily recognized. Its changes of form, brightness, and position are dealt with in relation to the tympanic inflammations by other contributors; yet some reiteration seems fair in regard to so important a matter. Based upon the glossy smoothness of its epiderm, the oblique position and the centrally depressed but slightly convex contour of the membrane, the light spot is generally seen downward and forward from the tip of the malleus handle, because this part only of the drumhead is at right angles to the line of illumination and of sight and can thus reflect back to the observer the light thrown upon it. The light spot can be shortened by slight depression, reduced to a point by more marked retraction, altered to a crescent or even to a peripheral line concentric with the annulus by distinct cupping, changed to a more horizontal or vertical direction by localized displacement, or divided fan-like by plications of a relaxed membrane. Its lustre may be dulled by œdematous maceration of the epiderm or lost when this is extreme or exfoliation is going on; and it is important in this section to note that these, which are often the earliest symptoms in the inflammatory process, are also generally the last persisting vestiges of its course. The light spot may be simulated by reflection from fluid in front of the drumhead or even from a mass of wax with its greasy lustre, when carelessly observed through a poorly illuminated canal; and it may be absent from view simply because the tortuosity of the canal humps up the floor or anterior wall so as to hide the region of the light spot from view.

Any change from the typical cusp-like triangle of light in the anterior inferior quadrant, or any reflection elsewhere from the surface of the drumhead, is to be closely scrutinized as anomalous if not strictly pathological. Depression of the flaccid "Shrapnell" membrane above the short process usually gives a point of light here which is of evil import, and the prominence of the posterior fold or of any other protruding portion of the membrane can give a reflection from its convex surface. The play of these light spots under the pneumatic speculum is also full of instruction, not only as to the past and present of the case, but also as giving at times indications for successful treatment.

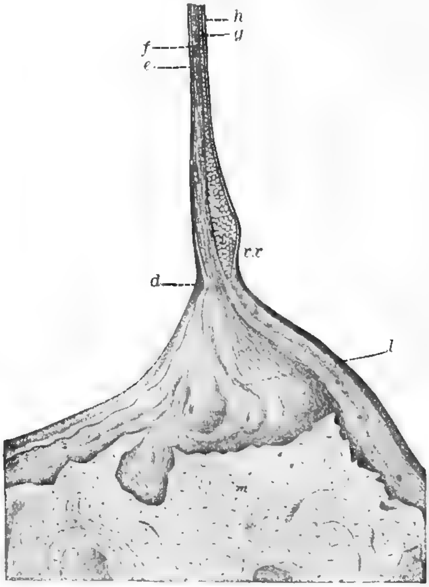


FIG. 1708.—Vertical Section of Lower Part of Drumhead. × 35. (Brunner.) On the left the skin of the canal thins as it passes over the tendinous annulus (*l*), until at *d* it is hardly more than epiderm (*e*); so too does the tympanic mucous membrane on the right (*h*). The membrana propria shows its radiate fibres (*f*) passing into the thickened fibrous annulus for insertion into the bony groove (*m*); while the transversely cut circular fibres, sparse at *g*, thicken at the margin into a firm ring (*xx*).

The color of the drum membrane may also show much of meaning. Normally of a rather bluish-gray, it ought

EXPLANATION OF PLATE XXV.

EXPLANATION OF PLATE XXV.

Fig. 1.—Normal left drum membrane as seen by suffused daylight.

Fig. 2.—Normal right membrane by lamplight.

Fig. 3.—Rupture of a partially thinned left membrana tympani by a kiss. Slight ecchymosis of the lower flap-like margin of the tear, with injection of the vessels of the manubrium.

Fig. 4.—Rupture of the left drum membrane by a box on the ear. Ragged rent with extravasation in the wound margins and injection of the vessels along the malleus handle. The rent extends nearly vertically behind the umbo and gapes slightly.

Fig. 5.—Rupture of the left membrane by puncture with a knitting-needle. Ecchymosis at the lower periphery of the rounded opening and injection of the manubrium vessels.

Fig. 6.—Double rupture of the right membrana tympani caused by a fall into the water. Slight injection. A semilunar rent in upper posterior quadrant and a longer, more crescentic tear below. Both are rather parallel to the circular fibres.

Fig. 7.—Ecchymosis on the right membrana tympani back of the tip of the malleus handle.

Fig. 8.—Pigmentation of the region of the umbo in the right membrana tympani—the remains of an extravasation.

Fig. 9.—Fracture of the malleus handle on the left, with malposition of the anteriorly displaced lower fragment. Retraction of the cicatrized neighborhood of the umbo, with distorted reflection of light and crescentic opacity of the lower anterior quadrant.

Fig. 10.—Injection of the cutis of the upper half of the right drum membrane. Slight dulling of the lustre or obscuring of details.

Fig. 11.—Radiate injection of the right membrana tympani. The malleus handle hidden by vascularization, and only the short process visible.

Fig. 12.—Acute myringitis of the left membrana tympani. Inflammation limited to upper half, where a hemispherical swelling hides all details except a faint indication of the short process.

Fig. 13.—Acute myringitis of the left membrane, with intense radiate dark injection. Exfoliated epithelium upon the posterior portion and a line of purulent fluid below.

Fig. 14.—Acute myringitis of the right membrana tympani, with two abscesses in the posterior half.

Fig. 15.—Granulations upon the left membrane in chronic myringitis.

Fig. 16.—Chronic myringitis, with concealment of all details by epidermal exfoliation.

Fig. 17.—Chronic myringitis of the left membrana tympani, with radiating injection, swelling of the entire membrane, and a sac-like bagging posteriorly filled with pus.

Fig. 18.—Ulceration of the right membrana tympani in chronic myringitis. Line of pus collection below.

Fig. 19.—Cholesteatomata on the left membrana tympani, after the removal of an impacted mass of cerumen. Injection of the vessels of the manubrium and dulling of the light triangle.

Fig. 20.—Exostoses upon the left drum membrane, before and behind the manubrium.

Fig. 21.—Sunken left drumhead in simple acute otitis media, with prominence of the posterior fold, dark coloration of the membrane, and bright point in front of the short process.

Fig. 22.—Strongly indrawn right drumhead in a case of acute simple otitis media. Marked prominence of the posterior fold; broken triangle of light and anomalous light spot in front of the short process.

Fig. 23.—Marked retraction of the left membrana tympani in acute catarrhal otitis. Both anterior and posterior folds prominent; incus shank discernible; "kneeing" of the intermediary zone, and dark coloration of the membrane.

Fig. 24. Injection and swelling of the left membrana tympani in acute simple otitis media.

Fig. 25.—Exudation in the right drum cavity, with curved surface line visible through the membrane.

Fig. 26. Exudation with angular surface line in the left tympanum; marked prominence of the posterior fold; punctate light spot in front of the short process.

Fig. 27.—Distention of the upper posterior quadrant of the left membrana tympani by serous exudation.

Fig. 28.—Sac-like distention of the posterior half of the right membrana tympani. Acute otitis media simplex, with diffuse injection of the membrane.

Fig. 29.—Bubbles formed by the air douche in the exudate within the left tympanum.

Fig. 30.—Distention of the left membrana tympani by exudate in simple acute otitis media. Bulging hyperæmia and swelling of the entire membrane.

Fig. 31.—Crescentic opacity of the posterior portion of the left membrana tympani in chronic otitis media simplex.

Fig. 32.—Peripheral opacity of the right membrane in chronic catarrh.

Fig. 33.—Flaky opacity of the left membrana tympani in chronic otitis media.

Fig. 34.—Sunken, clouded membrane, with prominent posterior fold and quadrate reflex.

Fig. 35.—Radiate atrophic areas in the opaque R. membrana tympani.

Fig. 36.—Atrophic left membrana tympani, showing the incudo-stapedial joint.

Fig. 37.—Atrophic and relaxed L. membrane in chronic catarrhal otitis.

Fig. 38.—Distention of the posterior half of the right membrana tympani by yellowish exudate.

Fig. 39.—Hyperæmia of the promontory in sclerotic catarrh of the tympanum, showing through the retracted membrane.

Fig. 40. Right membrana tympani, showing hyperæmia and swelling of its mucosa, and opacity in the membrana propria.

Fig. 41.—Milky opacity of right membrana tympani, with marked peripheral thickening and broken light spot.

Fig. 42.—Thickened and sunken left membrana tympani, with shining through of promontory; sclerosis.

Fig. 43.—Broadened and distorted manubrium; promontory discernible; sclerotic catarrh.

Fig. 44.—Attachment of the umbo to the promontory in case of marked retraction of right membrana tympani.

Fig. 45.—Adhesion of the upper posterior quadrant of the sunken drum membrane to the chorda tympani and the incudo-stapedial joint. Umbo in contact with promontory.

Fig. 46.—Adherent bands in lower posterior part of tympanum tying down the membrane.

Fig. 47.—Injection, swelling, and discoloration of the right membrana tympani with congestion of the manubrium; crescentic light reflex, and exudation in tympanum visible in lower portion. Acute suppurative otitis media.

Fig. 48.—Small perforation in lower anterior quadrant of the injected left membrana tympani. Exfoliation of epidermis hiding manubrium and leaving but faint indication of the short process. Small (pulsating) point of light from the fluid in the perforation. Acute otitis media suppurativa.

Fig. 49.—Purulent collection in front of lower portion of right membrana tympani hiding details.

Fig. 50.—The same membrana tympani after cleansing. Perforation back of umbo; gray-red membrane with irregular and dim light spot. Acute suppurative otitis media.

Fig. 51.—Pouting perforation of the posterior portion of the right membrana tympani. Membrane red, especially the very prominent posterior half. At the nipple-like apex of its lower part, a small perforation. Light reflex broad and faint, and short process barely discernible.

Fig. 52.—Small perforation in Shrapnell's membrane above the short process, from which a drop of exudation is hanging. Membrana flaccida red and swollen, and manubrium strongly injected. Broken light spot.

Fig. 53.—Recent perforation in the swollen and livid R. drum membrane, showing a (pulsating) point of light from the fluid within it. Membrane bluish-red, with sodden flakes of exfoliated epidermis giving here and there tiny glistening reflections. Vessels along malleus handle visible. Fluid in the bottom of the meatus gives a faint crescentic reflex.

Fig. 54.—Small perforation in centre of anterior half of membrane in chronic suppurative otitis. Membrane dull, with apparently thickened manubrium, and the mucosa of the inner tympanic wall dark red.

Fig. 55.—Perforation in the upper posterior quadrant of the right membrana tympani in chronic suppuration with caries. The dislocated incus is seen in the opening.

Fig. 56.—The same membrane several months later, showing thickening along the manubrium, the incus gone, and the stapes visible. Granulation masses hang out over the lower margin of the opening.

Fig. 57.—Reniform perforation in lower half of membrana tympani, with thickening of the membrane, especially along the malleus handle, and dulness of the surface. Glistening layer of fluid near anterior margin.

Fig. 58.—Heart-shaped perforation involving the major part of the left drumhead, leaving but a narrow remnant along the manubrium and at the periphery. Discharge has ceased and the tympanic mucosa appears yellowish-red, with a glistening streak posteriorly and branching vessels upon the promontory.

Fig. 59.—Central perforation of the middle of membrana tympani, with the tip of the manubrium projecting into the opening, through which the congested inner wall can be seen.

Fig. 60.—Partially adherent central perforation, with marked retraction of the membrane. Manubrium drawn in and up, and posterior fold prominent. A cicatricial band fastens the upper margin of the opening to the congested promontory. Comma-shaped reflection of light.

Fig. 61.—Double perforation in lower part of the left membrana tympani in chronic suppurative otitis media. Manubrium indrawn; light spot broken and tympanic mucosa injected.

Fig. 62.—Two large oval perforations of the right drum membrane, leaving but a narrow band of normal membrane extending up to the malleus handle. Anteriorly a whitish crescent of chalk deposit. Discharge has ceased and the promontory is reddish-yellow.

Fig. 63.—Large, round perforation, with marked retraction of the right membrana tympani, through the upper part of which the incus is discernible. Promontory red and hyperplastic.

Fig. 64.—Extensive destruction of the right drum membrane, leaving but a narrow periphery, with such retraction of the manubrium that it is almost lost to view. Thickening around the short process, and granular condition of tympanic mucosa.

Fig. 65.—Large perforation in lower anterior quadrant, filled by polypoid granulations of the mucosa of the tympanum, standing out as a raspberry-like mass in the plane of the membrane.

Fig. 66.—Perforation in lower quadrant, through which projects a knob of polypoid granulations hiding the margins of the opening. Manubrium markedly retracted, with prominence of the posterior fold. Crescentic opacity of the posterior part of the membrane.

Fig. 67.—Commencing cicatrization of a perforation below the umbo of a much retracted left membrana tympani, with "cone of light" extending in upon the bluish-gray scar tissue.

Fig. 68.—Scar in anterior portion of opaque and retracted left membrana tympani. Broadening of the tip of manubrium and area of thickening of membrane posteriorly.

Fig. 69.—Central heart-shaped perforation closed by a thin cicatrix. Light spot upon the depressed scar, and thickening of the perforation margins.

Fig. 70.—Central depressed cicatrix of L. membrane, with the tip of malleus handle projecting into the opening. Chalk deposit near anterior margin.

Fig. 71.—Almost complete replacement of the left membrana tympani by scar tissue. Marked retraction of manubrium, behind which the incus is visible. Broken reflex upon the indrawn cicatrix.

Fig. 72.—Two rounded cicatrices in L. membrana tympani, with retracted malleus handle. The membrane is thin and dark above, showing the descending process of the incus, but gives a marked cone of light below.

Fig. 73.—Cicatrized double perforation, with irregular chalk deposit below in the right drum membrane.

Fig. 74.—Sunken left membrana tympani, with thin cicatrix which closes a rounded perforation below, bellying out after the inflation.

Fig. 75.—Irregular crescent of calcification in posterior portion of the dull left drumhead.

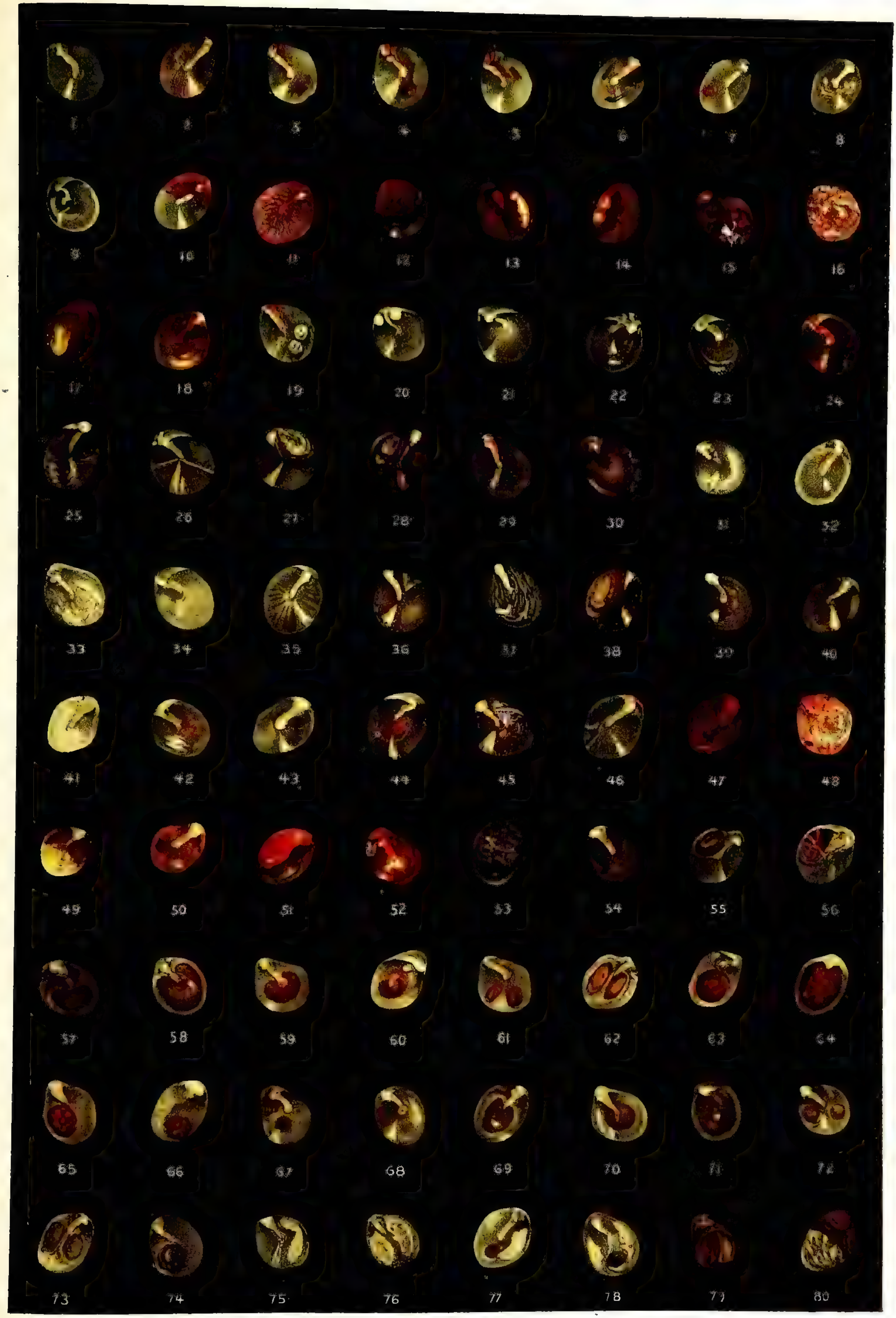
Fig. 76.—Two oval deposits of chalk in the left membrana tympani, occupying the greater part of each half of the membrane, and extending, on either side, close to the manubrium.

Fig. 77.—Right membrana tympani, showing a large calcified area anteriorly, a small one up and back, and a perforation below with chalk deposit in its thickened lower margin.

Fig. 78.—Left membrana tympani, with irregular chalky deposits on either side of a depressed cicatrix closing an oval opening, the lower margin of which is calcified.

Fig. 79.—Dark-red retracted left membrana tympani, with large perforation, out of the anterior portion of which a dark crimson polypus protrudes. Promontory yellowish-red.

Fig. 80.—Cholesteatomatous mass protruding from a perforation in the red and swollen right membrane.



The Human Tympanic Membrane, in Health and in Disease.

to be transparent enough to show much of the coloration of the parts beyond it; and the milkiness of opacities or the darkness of thinned areas serves easily to differentiate the affected portions. Yet it is fair to question how far we clinicians are really familiar with the ideally normal drumhead; certainly among hundreds of presumably normal school children I have seen few that even approached to a moderate ideal; and once, in a child with hearing that seemed to be absolutely normal, I found a drum membrane so delicate that it was almost as invisible as though a microscopic cover-glass had been placed across the canal. Such transparency or any approach to it deprives us, to a large extent, of our power to appreciate the extreme obliquity of the drumhead. On the other hand, an opacity makes this conspicuous and leads the beginner to think that such inclination is exceptional. Confusion in this regard is likely to continue so long as text-books teach that the adult drum membrane differs in its inclination from that of the infant, which every one knows to approach the horizontal.

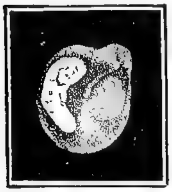


FIG. 1709.—Right Membrana Tympani, Showing an Oval Cicatrix Closing a Perforation in Front of the Manubrium. Posteriorly a large crescentic mass of chalk occupies the entire thickness of the membrane and stands out above it on both surfaces. From a preparation of Politzer's in the College of Physicians, Philadelphia. (Randall and Morse.)

Only a totally opaque drumhead, then, shows us solely its own color: in all other cases much must depend upon the degree of congestion of the inner tympanic wall and the degree to which its tint is revealed by the transparency and proximity of the drum membrane. The promontory is normally of a pale straw color and about 3 mm. distant from the umbo, but depression may bring this or other portions of the drumhead nearer to, or even into contact with, the underlying structures (Plate xxv., Figs. 39 and 44). The opacity may vary from epidermal thickenings or exfoliations or similar changes in the mucosa, to fibrous thickenings of the *membrana propria* or the chalky formations which succeed cellular infiltrations of slight vitality. The thinnings may be cicatricial closures of former perforations or atrophic areas hardly differentiable from such scars. While the thinnings may be non-inflammatory and due to mere pressure, the perforations, scars, or infiltrations point back to antecedent congestion, infiltration and consecutive changes, and often rebut any negative history furnished by the patient.

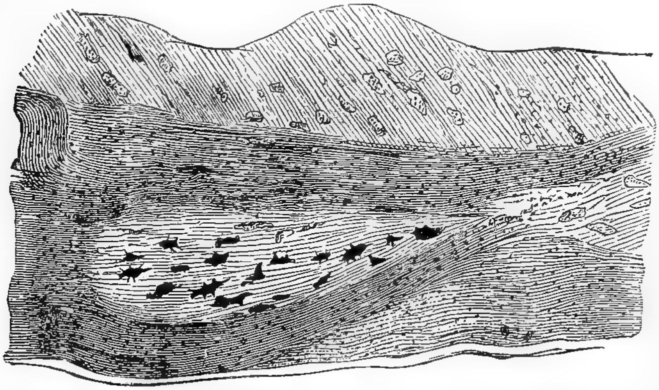


FIG. 1710.—Section of a Partially Calcified Membrana Tympani from a Young Man who Died of Tuberculosis after Suffering with a Purulent Otitis. The layers of the membrane are altered beyond clear recognition, and a small area in the midst of the calcification shows bone corpuscles. (Politzer.)

The diagnosis between epidermal flakes lying upon the drumhead and the fibrous or chalky areas in its substance is not always easy; but good illumination through the well-straightened canal can give enough parallax, especially in the rarer cases in which binocular vision can be used, to clear up many doubts; and the delicate use of the cotton-tipped probe can safely and quickly remove most of the merely adherent material. If the parts are moistened, this may be accomplished more easily, and any deposit of boric acid and such medicaments can be promptly removed. The fibrous plaques can usually be distinguished from the chalky by the interstitial vagueness of the former and the sharp-cut and apparently prominent character of the chalk. (Plate xxv., Figs. 31–34, 75–78). Such a chalky area is often thicker than the normal membrane and seems to stand out above its surface (Figs. 1709 and 1711); but it is really seated in the middle layer and is covered by a thin film of living tissue, which on the exterior, as seen in life, can be made to flush by touching it. Such congestion gives a yellowish or orange tint to the chalk plaque or can wholly hide it from view,—points that must be taken note of, especially in those cases in which chalk deposits have come to view as though newly formed within a few weeks. Months or years are usually required for such formations. The seat of chalk may be in any portion of the tense membrane, probably never in the flaccid; it is most commonly seen in the intermediary zone between the margin and the manubrium. Peripherally along the annulus and centrally along the malleus handle uncalcified areas are usually present even in extreme cases of calcification; and it is curious how extensive can be the process without interference with the hearing or with the even excessive mobility elicited by the pneumatic speculum. Virtual ankylosis of the malleus by a rigid membrane is possible, but must be extremely rare, since perhaps the only recorded case is that shown in the accompanying figure (Fig. 1712).

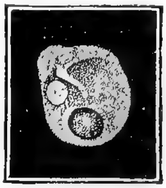


FIG. 1711.—Retracted Left Membrana Tympani, Showing a Depressed and Adherent Cicatrix below the Umbo, with Calcification of the Margin of the Perforation. Below the short process there is a round disc of chalk apparently standing above the general surface.

The margins of perforations, open or cicatrized (Fig. 1711), may show crescents of chalk; and the scar tissue itself may in rare instances undergo such chalky infiltration (Fig. 1709). In very exceptional cases true bone has been found (Fig. 1710); but usually we have merely the amorphous deposit of lime salts in the poorly vitalized infiltrating cells, as in other parts of the body. The fibrous thickenings of the drumhead differ principally in having had more vitality and thus having gone farther in the process of organization. They may be found encircling nearly all open perforations and many of those which have healed, forming a rounded rim contrasting more or less strongly with the thin scar tissue or the darker area of perforation. It is largely by the presence or absence of this marginal thickening that we judge whether such a thin area is cicatricial or merely atrophic (Plate xxv., Figs. 69–72).

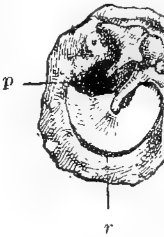


FIG. 1712.—Extensive Calcification of the Left Membrana Tympani. (View from within.) *r*, Narrow uncalcified portion at the lower periphery of the membrane: in front of the manubrium mallei a second narrow strip of uncalcified tissue is visible; *p*, an irregularly shaped opening in the upper posterior quadrant of the membrane. The malleus and the drum membrane are stiff and immovable. The incus and stapes are disconnected. The latter ossicle, however, is perfectly movable. Similar pathological alterations existed in the right ear. In both ears the patient was able to distinguish whispered words correctly at a distance of eighteen metres (the entire length of the room). (After Politzer.)

Far more important than some more conspicuous changes are the fibrous thickenings which may be seen in the drumhead (Plate xxv., Fig. 46) as expressions of adhesions to the structures within (Fig. 1713). These may seriously impede the due mobility of the ossicular chain, even when they are invisible or microscopically small. Many definite and still more numerous indeterminate or accidental bands span the various parts of the tympanic cavities, especially the attic, and may here immobilize essential parts of the conducting mechanism. Through normal or excessively thin membranes the delicate tendon of the stapedius can generally be seen emerging from the opening of the pyramid to insert itself upon the head of the stapes; and about this, as well as about the crura of the stirrup and from them to the walls of the oval-window niche, folds of mucous membrane are apt to stretch which need little inflammatory thickening to become obstructive. Some of them may bind the tympanic membrane to the incus shank, to the Troeltsch fold, or to the promontory. Similar folds may accompany the tendon of the tensor tympani; and although they are out of sight behind the malleus handle, their pathological contraction may be noted by the rotation of the retracted manubrium. In the pernicious or sclerotic catarrhs such lesions, especially at the oval and round windows, may cause great deafness with little or no external sign,—deafness much greater than that due to even extreme displacement of the ossicles and drum membrane by pneumatic pressure dependent upon Eustachian stenosis. This last, indeed, is often conspicuously absent and the tube gapes widely to admit air too freely,—in clear evidence that treatment *per tubam* must be medicinal, not mechanical. Some indication of the abnormal condition of the tympanic lining is often furnished in sclerotic cases by Loewenberg's test of inflating vapors of chloroform; for it must needs be a much altered mucous membrane to which chloroform feels cold; yet this occurs even in early stages and at times when visible congestion is present both in the drumhead and on the inner or labyrinthine wall of the tympanum.

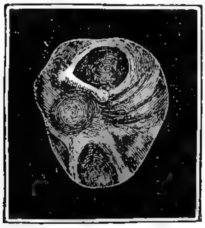


FIG. 1713.—Scarred and Depressed Drumhead, with Fibrous Bands Within. (From Politzer.)

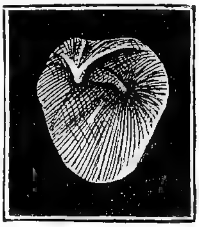


FIG. 1714. — Left Membrana Tympani of a Man Thirty Years of Age, in whom, as a Consequence of Coryza, a Marked Swelling of the Mucosa of the Tube has Occurred. The indrawn membrane is of violet-gray color. Relief of the extreme dulness of hearing was secured after three weeks' treatment by inflation. (Politzer.)

The depressed, retracted, or collapsed drumhead of chronic tympanic catarrh has been elsewhere considered, but some points in connection with it may be dealt with here. Primarily this abnormal position tends to affect the drumhead as a whole, for preponderant external pressure is the cause of the displacement. The umbo is deepened, the malleus handle is foreshortened, and the short process becomes more prominent, perhaps even thorn-like in its appearance, although rather because of the depression of surrounding portions than from its own protrusion; finally, the posterior and sometimes the anterior fold show an equal or even a greater degree of prominence (Fig. 1714). If retraction, strictly speaking, plays a part in producing these effects, it must be due to excessive tension of the tendon of the tensor tympani, and then usually shows itself in a slight rotation and forward displacement of the manubrium. One is sometimes puzzled how to explain why the malleus handle can be drawn so sharply in without being arrested by contact with the promontory, for its tip may be lost behind the short process, or in collapsed cases it may be drawn back and seem higher than the short process (Fig. 1718). Inflation may largely reduce the displacement (as shown in Fig. 1715) moving the malleus as well as the membrane farther outward than should be possible in health, or it may wholly fail to produce more than a tiny bleb-like protrusion, perhaps at the upper posterior margin, in demonstration that air has entered the tympanum, but has not been able to lift the depressed drumhead from its contact or adhesion with the inner wall. Such rigidity of the apparatus is not always due to attachments to the inner structures; for we must remember that the circular fibres of the membrana propria do much to give the funnel shape to the normal drum membrane (Fig. 1716) and tend to increase this when the other elements of tension are removed, as when the drumhead is cut loose. Hence a deep depression (Fig. 1717) might be maintained or even caused by a pathological increase of the influence of these fibres.

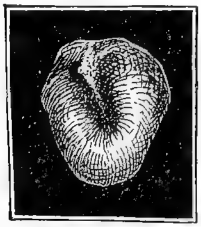


FIG. 1715. -The Same Membrana Tympani immediately after the Inflation. (Politzer.)

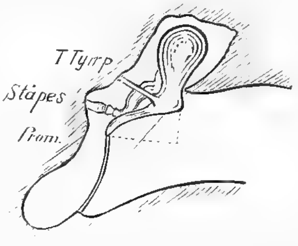


FIG. 1716.—Diagram of Normal Position of Membrana Tympani, Showing the Inclination of the Manubrium and Upper Segment to the Axis of the Auditory Canal.

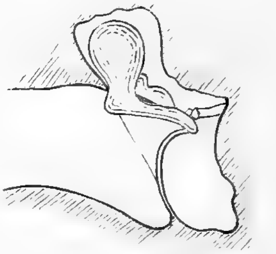


FIG. 1717.—Diagram of a Retracted Membrana Tympani, Showing the Manubrium Drawn almost Directly Inward.

Of some practical interest also are the partial depressions of the tympanic membrane, since they may escape hasty study and the appearance be considered normal; or they may be noted and misunderstood. More commonly at the lower anterior portion the drumhead may show a darker zone bordered peripherally by a sharp line of light reflection. This "Knickung" of the Germans—"kneeing," as I have termed it—is a terrace-like break of the contour of the membrane (Fig. 1719) which may be single or multiple (Fig. 1720) and the peripheral line of light comes from the edge of the undepressed membrane. Why this margin maintains its normal plane is evident from the section shown in Fig. 1708, where, at the margin, the circular fibres are so specially in evidence. When such a depression occurs near the middle of the drumhead it is readily mistaken for the surface line of fluid within the tympanum (Figs. 1723 and 1724).

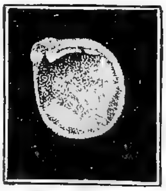


FIG. 1718. -Left Membrana Tympani of a Boy of Six Years with Nasal and Tubal Obstruction. Manubrium drawn up almost out of sight, the tip being higher than the short process; behind it the incudo-stapedial joint is visible, and below and posteriorly the dark niche of the round window is discernible. There is a faint reflection of light near the normal position and a stronger one on the promontory near the stapes.

The epidermal exfoliations from the surface of the drumhead concern us here in several relations. It is probable, as is elsewhere discussed, that the epithelium of the drumhead is capable of reproducing itself more rapidly than can that of any other part of the body. This has great physiological importance, since it is most active at the centre and as it were overflows the rest of the membrane from this point, seeming to push the rest of the epidermal layer before it to the periphery or out upon the wall. In health such a migration carries the older skin free of the drumhead, so that not even these tiny scales shall exfoliate upon its surface where they might interfere with the delicacy of its function. This cannot continue, of course, in disease, when the desquamation is exaggerated, as it is after all dermal inflammations; and much subjective noise and annoyance is sometimes occasioned by the presence of such flakes upon the vibrating membrane. This migration can transport superficial extravasations and other lesions to the periphery or clear of the membrane; and it has been claimed that even an artificial perforation, with an eyelet inserted to keep it open, has been observed thus to traverse a part of the drumhead. In medico-legal cases such change of position might give rise to conflicting testimony as to the location of lesions, which although intrinsically of no special significance, might be magnified into important discrepancies.

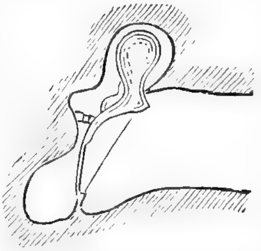


FIG. 1719.—A Schematic Section of an Indrawn Membrana Tympani, Showing Abrupt Change of Plane near the Lower Margin. The edge of the depression, being at right angles to the illuminating rays, reflects them back and forms a narrow glistening line; while the adjacent surface is depressed so as to give back little of the incident light.

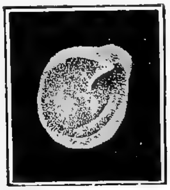


FIG. 1720.—Retracted Membrane, Showing Foreshortening of Malleus Handle, Prominence of the Posterior Fold, and Visibility of the Margin of the Pocket of von Troeltsch as it Passes Forward to the Manubrium. The light spot is shortened, and beyond it anteriorly are two parallel curvilinear bright lines, marking the edges of abruptly depressed areas of the drum-head, one within the other. From a girl of ten years, with long-standing nasal and tubal obstruction.

The bleb-like liftings of the epidermis, which form in some acute cases (Fig. 1725), are sometimes slow to detach themselves, and may present puzzling appearances; and localized hyperplasia may form wart-like growths or epidermal horns as in Figs. 1721 and 1722. The pearly tumors (Plate xxv., Fig. 19), of which Politzer has published a notable case (Fig. 1726), have always, in my limited observation of them, occupied the vicinity of a former perforation. They are cystic collections of epithelium and cholesterin and doubtless mark an involuted perversion of the epidermizing process. Of more importance, by far, is the occasional tendency of the epiderm to overrun the margins of a perforation. This results not merely in "skinning over" its edges and causing it to remain open, but also, by establishing grafts of epidermal flakes upon the mucous surface, in setting up a train of pathological changes the full importance of which we are as yet scarcely able to appreciate. It may prove to be no overstatement if I say that all chronic suppurations owe their persistence, in greater or less degree, to the resulting formation of cholesteatomatous material.

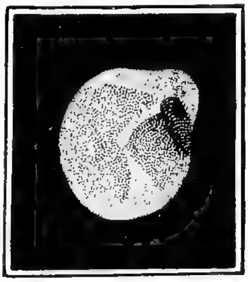


FIG. 1721.—Horn-like Growth in a Man Aged Seventy. A blackish conical mass, looking like cerumen, lay in front of the right drum membrane, with its outer part touching the anterior wall of the meatus. When seized with the forceps it was found to be attached to the short process, but was removed by slight torsion and traction. It proved to be a cuticular horn, 6 mm. long by 2 mm. in diameter, composed of cap-like layers arising from the short process. No reaction nor recurrence followed its removal.

Perforation of the drumhead will be considered elsewhere in relation to the suppurating process of which it is a distinguishing characteristic. We may here deal with its production by trauma, by external or intralamellar ulceration, or by the more usual outbreak of serous, mucous, or purulent fluid from the tympanic cavity.

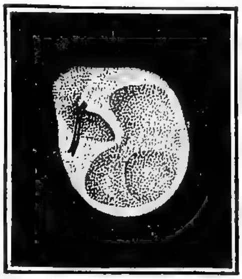


FIG. 1722.—The Left Membrana Tympani of a Man Thirty-Six Years of Age, in a great Measure Destroyed by Scarlatinal Otitis in Childhood, only a Triangular Portion Remaining Anteriorly. Its place is supplied by a thin cicatrix irregularly depressed, leaving the malleus apparently prominent, although really retracted and fast to the promontory. From the short process a blackish string, slightly bifurcated at its tip, projects forward and downward and moves but slightly under pressure.

Ruptures of the drum membrane are generally described as straight or angled linear tears, gaping so little that the blood-stained margins alone mark the site until, on inflation, the lips of the opening are separated by the escaping air. Sometimes they are round, oval, or polygonal; and Politzer seems more frequently to have met them in this form. They are rarely multiple (Plate xxv., Fig. 6) and their form doubtless depends upon the relation of their direction to that of the fibres of the *membrana propria.* Helmholtz claimed that rupture of the circular fibres should precede that of the radial, which would explain such radiate openings as Politzer has depicted (Fig. 1729). The majority of those which I have seen were vertical slits back of the manubrium, as shown in Fig. 1728. Those due to penetration by a vulnerating body are usually round (Plate xxv., Fig. 5) and are more apt to be followed by suppuration, perhaps from injury to the inner wall. In such a case, as a matter of course, the suppuration would soon efface any characteristic appearance.

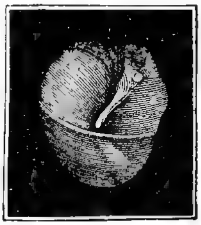


FIG. 1723.—Collection of Fluid Exudate in the Lower Part of the Tympanum, Marked by a Glistening Line Across the Membrane. From the right ear of a young man in the middle of an acute coryza. Cure by inflation. (Politzer.)

Ulceration of the outer surface of the drumhead, as shown in Fig. 1731, is rare; and interlamellar abscess is no more common. The latter has been described as a yellow point, which resembles the localized pointing of pus that is about to escape from the tympanum. The diagnostic point has been made that pressure with a probe will usually indent the prominent and inelastic abscess, and this dimple will remain for some time, as shown in Fig. 1730. The contents of such an abscess are also unaffected by inflation of the tympanic cavity; and, on evacuation, no complete perforation will be found. Such abscesses may burst inward instead of outward (Politzer), as recognized by the disappearance of the pus and the distention of the empty sac when the air douche is used. Toynbee is authority for numerous instances of ulceration found post mortem; they were limited to the cutaneous or the mucous surface and were sometimes extensive. Yet they must be very rarely recognized in life, and such appear-

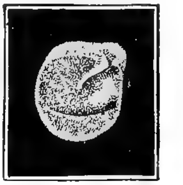


FIG. 1724.—Marked Partial Retraction of the Middle of the Right Membrana Tympani, in a Case of Chronic Catarrhal Otitis. The lower portion is in about normal position, and the manubrium and upper part are not greatly indrawn; while the middle portion is so abruptly retracted as to form a sharp "knee" overhanging the dark depressed area above it. The appearance presented to the eye is that of a glistening line running across the membrane near its middle and closely simulating the surface line of an exudate in the cavity. In front of the manubrium is visible a whitish ill-defined thickening.

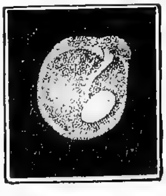


Fig. 1725.—Delicate Bleb on the Drumhead in Acute Myringitis.

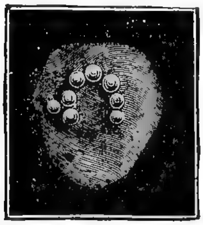


Fig. 1726.—In a young man whose ear affection had lasted a year, there was a tiny perforation in the lower anterior quadrant of the left membrana tympani, and upon the upper part of the drumhead were eight glistening globular bodies of pinhead size arranged in a semicircle. These were found with the probe to be hard and firmly seated upon the membrane. (Politzer.)

ances may generally be ascribed to the usual cause of perforation, viz., the outbreak of fluid from the tympanum. Such an occurrence is very common; and the history of any flow from the ear generally points to such perforation. Few children escape one or more attacks of earache; and these acute inflammations are as often relieved by an escape of exudate through the drumhead as by one that follows the channel of the Eustachian tube. The quantity of the fluid which escapes is, in many instances, not more than a drop or two; consequently it may be wholly unnoticed, and the denial that there has been any discharge may be entirely honest, however unequivocal the evidence of perforation. In this connection we must insist that there is no anatomical or clinical basis for the claim that a "foramen of Rivinus" should normally be present above the short process. It is absent in the embryo and the infant and appears with increasing frequency only as the child grows older (in ten per cent. of the children—most of them over ten years of age—which were examined by me for this purpose). In adults such an opening or scar may be noted by careful scrutiny in twenty-five per cent. of all drumheads. Most of these cases can give no history of discharge; but we often find even grosser lesions with a like negative history. The presence of such an opening or scar confirms my claim that disease in the attic is not necessarily severe and intractable, bad as certainly are many attic suppurations with perforation in the flaccid membrane (Fig. 1733).

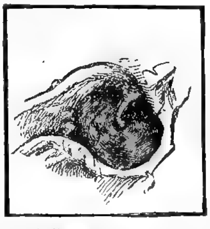


Fig. 1727. Irregular Linear Rupture of Posterior Portion of Right Membrana Tympani, with its Edges in Apposition. (Toynbee.)

The tense membrana vibrans is much the more frequent seat of such an outbreak of discharge from the tympanum, and most authorities state that it is most common in the lower anterior or light-spot region. A summary of 1,000 consecutive cases in my practice was made by Dr. Barton H. Potts and it shows only 25 per cent. at this part as against 37 per cent. down and back, and 16 per cent. up and back. The Shrapnell perforations were 10 per cent. and those called central (often too large for their region of origin to be longer determinable) were less than 7 per cent. I feel confident that more extended observation will show that the upper posterior region, which is the site of the most common and conspicuous distention, will be found to have a larger proportion of perforations than that which has just been given.

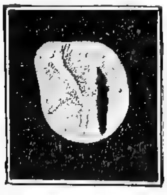


Fig. 1728.—Rupture of the Left Membrana Tympani. A vertical gap extends almost across the posterior half of the membrane, and the vessels are full, especially behind the manubrium.

While the form of the opening is as varied as its site, it generally begins as a small round yielding of the distended tissues (Plate xxv., Fig. 51), and only in the very septic conditions, as in scarlet fever and diphtheria, is there a rapid loss of substance by ulceration to enlarge it or even to destroy almost every vestige of the drumhead. Almost always in infancy, and frequently throughout childhood, the perforation is but a pinhole at the apex of the bagging portion of the membrane; and this nipple-like or pouting perforation may be recognized only by the drop of discharge which forms upon it almost as fast as it can be wiped away (Plate xxv., Fig. 52). The persistence of such a protrusion after an opening has formed doubtless marks some impediment of free drainage; and in adult cases this often has its serious aspect (Fig. 1732). In early life, however, and in the presence of mucopurulent discharge of no great virulence, it may be regarded with less concern. It serves as a complete bar to penetration of medicaments from without, and therefore is an indication for the use of heat by the douche as our best astringent; for the heat can penetrate where the fluid which conveys it to the bottom of the canal fails to pass. It is claimed that such openings are specially liable to clogging under insufflations of powdered boric acid, a phenomenon which depends principally on the insolubility of boric acid in mucus, and which therefore brings it in all such cases under the ban which forbids the use of any insoluble powder. Such incomplete drainage may also afford an indication for operative enlargement of the opening; but incision through such a perforation may serve only to freshen its edges for premature closure and wholly defeat the intention of the operator. It is better to incise, if at all, freely at the periphery of the membrane, avoiding the site of the perforation; but in many cases it seems simpler and better to introduce a pair of fine forceps into the perforation and by separating the blades to cause slight divulsion, thereby securing a more patulous condition with lessened tendency to close. As there is frequently a tendency of the swollen mucous membrane to prolapse into the opening and limit the exit, the application of silver or other astringents to the edges of the perforation may cause the tissues to retract and thus favor drainage. The same result may be attained at times by light dusting with boric acid, and the assertion that this medicament will enlarge perforations testifies in some measure to its efficacy.

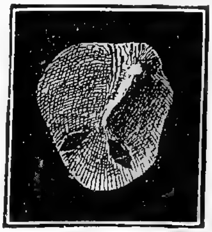


Fig. 1729.—Double Rupture of Right Membrana Tympani in a Woman of Thirty, Produced by a Fall upon the Ear—seen on the Third Day. The two tears have radiating directions, and show marked gaping. (Politzer.)

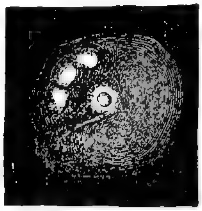


Fig. 1730.—Interlamellar Abscesses of Right Membrana Tympani, one at Umbo Showing the Pitting caused by Pressure of a Probe. Three others are seen backward and upward. (Schwartze.)

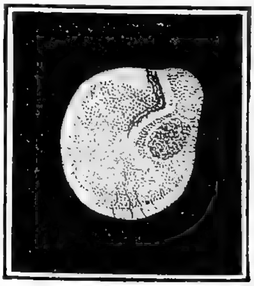


Fig. 1731.—Ulceration of the Right Membrana Tympani of a Man Sixty Years of Age after the Removal of a Hard and very Adherent Plug of Cerumen. A dark red rough and moist surface was seen in front of the malleus handle, bounded by a raised edge of cuticle. The remainder of the membrane was nearly normal except for injection, and the light spot was merely lacking in brilliancy. Examination of the ceruminous plug showed that it had been in contact with the ulcerated surface. Healing was prompt under boric acid powder.

With any increase in the size of the opening a dark hole may be seen when the occluding discharge has been removed; and in all acute cases any fluid within the opening can generally be seen to pulsate (Plate xxv., Fig. 48), in evidence that the arterial pulse is propagated into the distended capillaries of the tympanum. The proximity of the carotid has been cited as a cause for this visible pulsation (which may be as throbbingly felt in the inflamed finger tip). Such pulsation is therefore usually indicative of perforation and is noted only in or near the opening; yet in rare cases the unruptured membrane has been observed to pulsate, but only when thinned to the verge of rupture. (Compare Fig. 1749.)

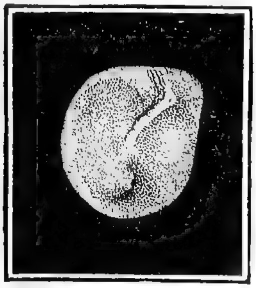


FIG. 1732.—Right Membrana Tympani of a Man Thirty-two Years of Age, Recently Recovered from Typhoid Fever. Muco-purulent catarrh of the middle ear of two weeks' duration. Below the umbo is a reddish-yellow protrusion, yielding but little on pressure, from the point of which the discharge flows, and on being cleansed, a minute opening is visible. General injection of membrane, especially behind the manubrium. Treatment failed until a good-sized opening was made with a paracentesis needle; then prompt recovery ensued.

Further enlargement of the opening is apt to assume a more oval form, partly because of the obliquity of the membrane and its foreshortening. Near the upper back margin this may make the perforation appear even slitlike; or, if its margin be swollen, no visible opening may be noted (Compare Fig. 1738), although the curved probe can be readily carried through it. This is the more important since the peripheral perforations at this locality are apt to indicate carious involvement of the shank of the incus (Plate xxv., Figs. 55, 56) or of the bony tympanic margin, and to demand prompt recognition and vigorous treatment. Still larger openings are commonly reniform (Figs. 1738 and 1746) and embrace the tip of the hammer handle (Plate xxv., Figs. 58 and 59), which may seem to protrude naked into the opening. Such denuding of the malleus is not in reality very common and the cotton-tipped probe will not catch upon it, for the condensed drumhead tissues still cover it and are well nourished by its vessels. Caries and visible truncation usually follow quickly actual denudation. Destruction of the drumhead may be complete, leaving no visible remnant; but more often there is a rim of the thicker tendinous annulus recognizable throughout more or less of the circumference (Plate xxv., Fig. 64), and this may form a perfect basis for regeneration of a cicatricial membrane after the destructive process has exhausted its force.

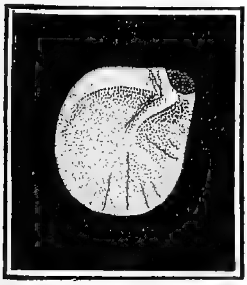


FIG. 1733.—Right Membrana Tympani of a Boy of Five Years, with Constant Discharge for Three Years. A perforation about 1.5 mm. in diameter is with difficulty seen above the short process, and intratympanic injections bring away epithelial flakes and masses of fœtid secretion. The rest of the membrane is slightly opaque, thickened, and injected.

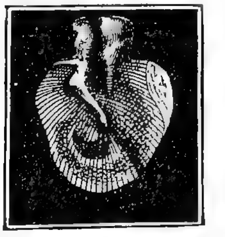


FIG. 1734.—Large Loss of Bone at the Inner End of the Upper Wall of the Meatus, in a Woman Twenty-six Years of Age, in whom the Tympanic Suppuration began in Childhood, and Ceased only a Few Years Since. Membrana tympani dry, gray, and opaque, retracted down and forward from the umbo, atrophic behind the manubrium. Through the opening are seen the malleus head, the anterior ligament, and the body of the incus with its long process. A very delicate membrane which closes the opening and applies itself closely to the ossicles, bellies out on inflation. Hearing, 0.5 metre for acoumeter, 5 metres for loud whisper. (Politzer.)

The perforation of the drumhead is generally single, but it is not unnatural, when one opening is ill-placed for draining the complex cavity, that another should result from the action of retained fluid (Plate xxv., Figs. 61, 62, 72, and 73). Especially is this the case as regards the attic with its subdivided area, which may require several openings in the flaccid membrane to drain it, irrespective of openings in the tense membrane below. The objection often raised, that high-placed openings (Figs. 1733 and 1736) are ill suited for drainage, is usually specious. Whoever raised this objection ignores the fact that most persons are recumbent at least one-third of the time, and, furthermore, that capillary attraction counts for more than gravitation in this matter of draining the tympanum.

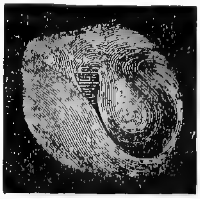


FIG. 1735. — Purse-like Distention of the Upper Posterior Quadrant of the Left Membrana Tympani. (Schwartze.)

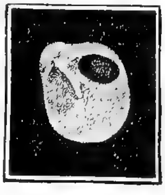


FIG. 1736.—Perforation of Upper Posterior Quadrant, such as sometimes remains after rupture of the distended portion shown in the previous illustration.

As stated above, I believe that the majority of perforations are located in the upper quadrant and are so efficient that they permit of prompt cure with little or no recognizable scar. Perforations occur high up because in this region there is retention of fluid which is not drained away by the normal channel of the Eustachian tube. Yet the occurrence of multiple perforations in the tense membrane should always raise a question as to the existence of a tuberculous process; and when we come to investigate these cases we shall often find that there is a prolonged expiratory sound, if not more marked trouble, at one or both lung-apices, or that the family history shows a tendency to consumption. At times the perforations almost merit the term "sieve-like," as in the cases figured (Figs. 1739 and 1740); and if the process is notably painless and the drumhead presents rather a pallid than congested aspect, we may feel nearly sure of the diagnosis even though otherwise unsupported. The fact that the promontory, in the later stages of such cases, is not infrequently denuded of its covering of mucous membrane, or may even be carious, may likewise be regarded as an extremely suspicious circumstance. Miliary tubercles have been noted in the drum membrane as yellow points which rapidly soften and leave perforations; but I cannot say that I have ever recognized them, and I know of no certain means of differentiating them from the more ordinary pointing of retained pus, unless it be in the fact of their multiplicity.

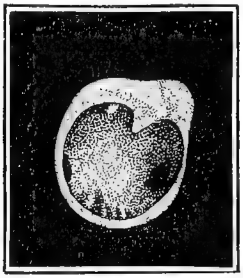


FIG. 1737.—Right Ear of a Boy, Eight Years of Age, with Long-standing Suppurative Otitis after Scarlatina. The membrane is extensively destroyed, leaving but a narrow margin all around, except where a triangular portion remains along the retracted manubrium. The tip of the long process of the incus is just visible posteriorly, the niche of the round window appears behind, and the irregular depressions of the floor of the tympanum may be seen below. Anteriorly, we look into the Eustachian tube, as far as to the isthmus.

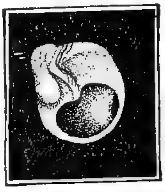


FIG. 1738.—Left Membrana Tympani of a Woman Thirty Years of Age, with Long-standing Purulent Otitis Media. A reniform perforation involves much of the lower half of the drumhead, and a polypus arises by a narrow peduncle in front of the short process. Upon its removal, no perforation was recognized at its point of origin.

The usual tendency of a perforation, of whatever size and however produced, is toward closure. Even the most thorough excision of the entire drumhead has been followed by complete regeneration; and Kessel urged that the tympanic margin should be chiselled away in such cases if a permanent opening was desired. The healing takes place more promptly in youth than in later life and in acute than in chronic cases; yet it is sometimes a far slower process in the case of small than in that of large openings,—the reason being that the "skinning over" of the margins by ingrowth of the drumhead epithelium suppresses the growth of reparative granulations. The further great importance of this process in the production of cholesteatoma and the renewal or maintenance of suppuration will be dealt with later.

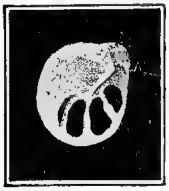


Fig. 1739.—Right Membrana Tympani of a Man, about Fifty Years of Age, Showing Four Perforations in the Lower Portion. The narrow, most posterior opening closed under observation. (Patient had laryngeal tuberculosis.)

Drumhead healing in its simplest form is seen in many of the acute cases, in which the perforation has been a mere pressing apart of the tissues, especially the fibres of the membrana propria, with little or no loss of substance. The tissues come together and unite as if by serous agglutination, the epidermal and the mucous epithelium are promptly renewed, and in a short time every vestige of the opening has disappeared. Where there has been loss of substance this must be replaced by new tissue, and in the traumatic ruptures, even when promptly healed without suppuration, there is apt to be enough new tissue to make a permanent scar, often more visible than the inconspicuous rent. Such cicatrices involve only the fibrous layer, as a rule; for the epithelial and mucous surfaces soon lose any altered appearance if the supporting tissue approximates the normal. This it often does, and it is at times easy to overlook large cicatrices or, in recognizing their thinness, to be in doubt as to whether the condition is one of atrophy or of a healed perforation. Most perforations present a thickened margin, which may be recognizable after they have healed and which furnish the characteristic which distinguishes them from mere atrophic areas. This thickening contains most of the peculiar substantia propria fibres which spanned the site of the opening, and in the healing process these may be drawn back into place; but regeneration of these fibres probably does not occur, although it has been reported. Some new tissue will be present to unite the separated fibre ends, but this may be hardly discernible under microscopic study. Most commonly, in openings of any size, granulations form on the margins; they arise from any or all of the layers, and are clinically recognized as a pink or red edging. They grow inward, cicatrizing as they do so, and drawing inward, like a sphincter, any of the old tissues which may be present. Finally, they meet and coalesce. Vascularization or other factors may make this process unsymmetrical, and the new tissue may be even a tongue-like growth which proceeds from one side and closes all but a cleft at the opposite margin. I have observed this especially in perforations healing under the stimulation of a paper patch. This new tissue is soon converted into a fibrous scar, but it rarely has much of the rigidity of the original membrane and almost always shows a flaccidity and undue mobility which are apt to increase. Hence such scars are generally more or less depressed and may even collapse into contact with the inner structures of the drum cavity (Figs. 1741 and 1743). They may not only fail to serve as parts of the vibrating membrane but may even hamper its movements or those of the deeper structures, blanketing the stapes if in its region and seriously interfering with hearing. On inflation they often bag out into the canal in single or multiple bosses and may furnish strikingly variable pictures as shown in Figs. 1742 and 1744. So complete may be the depression of a scar that it may be practically unseen, its peripheral portions hiding beneath the perforation margins, while its centre, instead of being concave and giving back the usual reflection, may apply itself to the convex promontory and seem but a glossy coating of its surface (Fig. 1745 and 1746). The perforation may therefore seem still open; but inflation will usually distend its cicatrix conspicuously in front of the drumhead. Such flaccid scars often interfere with the hearing. Multiple incisions have therefore been made in the hope of effecting a firmer cicatrization; but I have generally found that better results may be obtained from McKeown's plan of painting the distended drumhead with contractile collodion. The temporary splinting is accompanied by enough irritant effect to thicken up the flaccid tissue, and even though there is little visible difference, there is often much gain in hearing after a few repetitions.

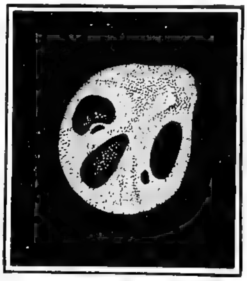


Fig. 1740.—Right Membrana Tympani of a Man, Forty years of Age, who Died about a Year Later of Tuberculosis. An oval perforation occupies the anterior portion of the membrane, a more pear-shaped one is down and back from the umbo, and a third, of kidney shape, is up and back. Two small and elongated openings are close to the first and the third. The membrane shows plications below the umbo.

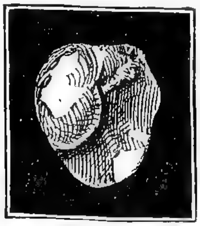


Fig. 1741.—The Same Drum Membrane immediately after the use of the Air Douche, which raises his hearing nearly to the normal. (Politzer.)

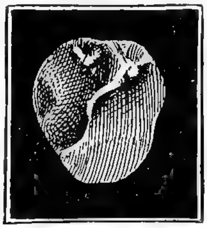


Fig. 1742.—Right Membrana Tympani, in a Boy Seventeen Years of Age, who has Suffered with Chronic Middle-Ear Catarrh for Eight Years. Naso-pharyngeal catarrh with great swelling of the mucous membrane of the tube. The depressed area rests upon the inner wall and shows the incudo-stapedial joint. (Politzer.)

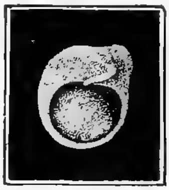


Fig. 1743.—A large rounded loss of substance of the membrana tympani below reaches up to the tip of the manubrium, which projects slightly into the upper margin. It is closed by a delicate cicatrix applied to the promontory and moulded upon its inequalities. The edges of the depression are sharp-cut and overhang, so that the area seems an unclosed perforation.

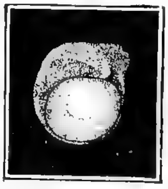


Fig. 1744.—Inflation of the middle ear forces the delicate cicatrix out like a bubble into the meatus, where it seems larger than the opening and hides its edges and the handle of the malleus. In a few minutes the distended sac loses its tension, and becomes plicated as it collapses, soon to resume its old position in contact with the inner tympanic wall.

Small scars, however much they may collapse, and provided they are not located directly over the stapes, rarely disturb the hearing so long as they remain free; but adhesion to the underlying structures, especially those of the inner wall (Fig. 1747), is usually very disabling to the conducting apparatus. Such attachment may be primary, in that the remains of the drumhead are united thus to the tympanic walls by granulations that should have built up a cicatricial closure of the perforation; but it may also be secondary to the collapse of a full-formed scar. Not very rarely vigorous inflation or pneumatic massage is seen to be followed by extravasations in a scar lifted from a contact that has given rise to inosculation of its vessels with those of the underlying tissues. Where the margins of the open perforation are bound down to inner structures, very puzzling pictures are sometimes presented; for we generally recognize a hole by its sharp-cut margins, and with the melting of these into other parts landmarks may be wholly effaced. In very rare instances a free cicatrix may form in advance of parts thus bound down and such a condition of "detachment of the manubrium" results as is shown in Figs. 1745 and 1748.

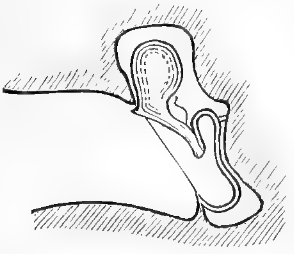


Fig. 1745.—Diagrammatic Section of a Large Free Cicatrix Depressed into Contact with the Inner Tympanic Wall and Stretched in all Directions, so that the Margins of the Perforation overhang it.

Occasionally a complete new membrane may form external to the annulus, arising apparently from the union of granulations which spring from the canal walls. Those which I have met were located in the inner third of the canal, at the upper part, very close to the drumhead; but they were placed almost at a right angle to the axis of the canal, with none of the obliquity of the real drumhead. The usual landmarks of the drumhead were also lacking. As they probably impede hearing very little if at all and are excellent protective partitions for the drum tissues, interference for their removal is rarely advisable.

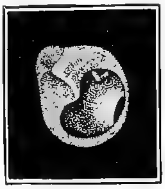


Fig. 1746. A large reniform perforation of the left membrana tympani, in a man twenty-one years of age, is closed by a delicate, almost invisible cicatrix closely applied to the underlying structures. The niche of the round window posteriorly, and the incudo-stapedial joint above, are seen as clearly as though not covered. The tube was but slightly permeable, and little functional improvement or change of the picture was afforded by inflation.

Where healing of a perforation is long delayed and it seems advisable to secure the protective effect of an intact drumhead, this result may often be promoted by the surgeon, either through freshening the edges by rubbing or by stimulants such as silver or trichloracetic acid (25 per cent.), or—more safely—by Blake's method of covering it with a patch of thin writing or tissue paper. This may be moistened so that it shall adhere by its own sizing, or it may be coated with a little glycerin or boroglyceride of tannin and carried by a probe or forceps into snug contact with the margins. In a week or two it may be washed away and replaced if the healing is incomplete; but a dry non-vitalized opening that has been rather widening than narrowing for weeks or months, will sometimes be found perfectly healed at the end of a week or ten days. The lining membrane of the egg-shell has also been used, but with doubtful advantage. In this delicate procedure full recognition of the obliquity of the drumhead is essential if precise placing of the patch is to be secured. It is also very important to warn the patient that a decided loss of hearing may be the primary result of such interference; for otherwise he may be greatly disturbed by this temporary change for the worse.

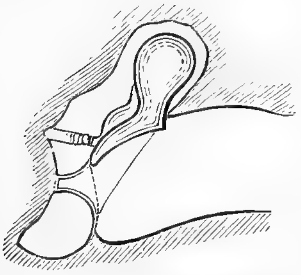


Fig. 1747.—Diagrammatic Section of a Small Depressed Cicatrix attached to the Promontory.

Perforations in the flaccid membrane show a much less marked tendency to close, and this is especially true of those cases in which there has been any caries of the adjacent margin of the scute. Some of this is ascribable to the ingrowing of epithelium and the formation of cholesteatoma within the attic and antrum. The rapidly proliferating epithelium (Blake has shown that the growth is most rapid above) transplanted to the succulent mucous surface grows with unprecedented activity. Desquamation takes place promptly and finds the region unprepared to rid itself of the débris. These cavities are naturally lined with cells which break down into mucus and are supplied with cilia to sweep the fluid down the Eustachian tube; but the cilia, if not already destroyed, are incompetent to move the flakes of epidermis, and these remain to excite further the proliferating tendency. Onion-like masses are formed as layer is added to layer, and under pressure of the collection the bony walls may undergo absorption, the soft tissues stretch or yield, or, with the help of any infective material that may be present, a suppuration may be set up. This is likely only to swell the collection and painfully increase the destructive pressure. Fortunately, the outward direction often offers the least resistance, and through the old perforation or one new-formed the pearly mass may escape into the canal; too frequently, however, it is only by absorption or carious destruction of the bony walls that an exit can be secured. The ossicles, if uninjured by the earlier suppuration, are apt to suffer displacement or caries, granulations form as the natural protest of the parts, and, as a result of their endeavor to rid themselves of the really foreign material, all the malign elements of chronic suppuration are called into activity.

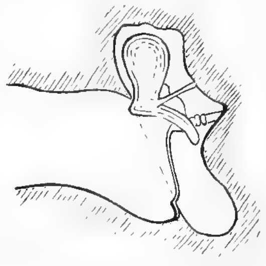


Fig. 1748.—Diagrammatic Section of the Same Case, Showing the Knee Below and the Manubrium Drawn in Behind the Middle of the Membrane.

Strictly, the cholesteatoma should be called a *product*, not a neoplasm, although its analogy to the pearly nodule of epithelioma is very close; yet it acts at times almost as destructively as does a vascular growth and has a similar tendency to renew itself after removal. Absorption or carious destruction of the scute, or so much of it as forms the outer wall of the affected region, may afford adequate exit for the material so often as it forms, although the soft parts are apt to grow more or less over the gap and a parturition in miniature has to be suffered each time that a mass finds exit. In some cases, even without such opening up of the affected area, the proliferative tendency seems to wear itself out; but more often there is at best recurrent suppura-

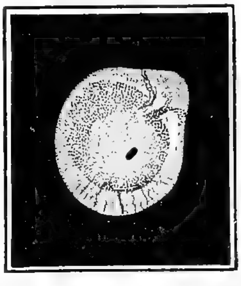


Fig. 1749.—Right Membrana Tympani of a Woman, aged Forty-five, with Long-standing Intermittent Suppuration of the Tympanum Recently Recurring. Small central perforation in a free cicatrix stretched across in front of the lower half of the manubrium. Periphery of membrane thickened and opaque, calcified anteriorly; the central portion depressed and presenting a sharp "kneeing" below. Closure of the perforation by drying of the scanty discharge leads to further depression of the cicatrix, and brings it into contact with the lower portion of the manubrium, which is then seen to be entire and perhaps bound down to the promontory. Before rupture the thin scar was visibly pulsating and gave way spontaneously under observation.

tion,—"repeated gatherings" as the sufferer naturally calls them,—if not a persistent discharge with exacerbations, until some serious accident occurs or the surgeon forestalls it by operation. No branch of surgery has made greater advance within the past active decade than has otology in dealing with these cholesteatomatous conditions and their results. It is a subject for most earnest congratulation that we are growing into a better comprehension of the pathological principles which underlie these cases, and while our diagnostic skill is increasingly efficient in bringing them to recognition and clearing the mystery which often enshrouded them, we are also more prompt and rational in combating them. For a long time to come, however, we may expect to see cases in which, owing to neglect (on the part of the patient rather than on that of the physicians), these cholesteatomatous masses continue to exert their injurious effects unchecked. I have repeatedly seen the entire mastoid hollowed out into one huge cavity filled with such a laminated mass, with absorption or caries of the inner table and serious pressure on the dura and brain. Knuckle-like portions may invade the cranial cavity and give all the pressure symptoms of brain tumor, or the whole mass, with the pus which it has induced, may enter the cranial fossa as an extra-dural abscess and make its way outward through the squama. In this, or in one of many other ways, which will be set forth in detail in other articles of this group, cholesteatomatous masses may involve extensive portions of the temporal bone and set up a variety of pathological processes of the most serious character.

Caries of the ossicles is to be expected in many of these cases; in some of them, indeed, it may have already led to their dislocation or exfoliation before the patient is first seen. If the disease has not advanced as far as this it may often be stayed and the ossicular chain restored to usefulness or at least to innocuousness. It is often most surprising how perfect the hearing may be with the attic full of pus and the ossicles bare or clearly carious. The most vulnerable because least vascularized portion is the shank or descending process of the incus, and its destruction sets the stapes free of hindrance, as well as of help, from the rest of the ossicular chain. The neck of the malleus, where Prussak's pouch holds infective material in contact with it, is next in the frequency of its involvement; yet it may be eaten through and the head loosened or lost without great impairment of function. These and many other carious portions are after all almost microscopic in size, and operative interference on a very minute scale may prove adequate for securing resolution. Thus, for example, rubbing the bare surfaces with a bare or cotton-tipped probe may not only reveal but at the same time sufficiently curette the caries, and a speedy and lasting cure has frequently rewarded this procedure in my experience. Persistent polyps or granulations justify suspicion of the integrity of some portion of the bony structure, even when it wholly eludes careful probing; but painstaking, and if need be painsgiving, search and minutely thorough use of the measures elsewhere detailed will bring most of these cases to an apparent cure. This, however, should be regarded as a mere truce, and minute crusts should be searched for at intervals; and when found they are often best removed dry, so that we may see if the under surface is wet with recent discharge.

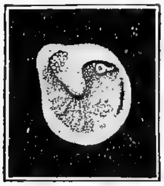


FIG. 1750. Extensive Destruction of Membrana Tympani, Partially Replaced by a Retracted and Plicated Cicatrix. The malleus handle greatly thickened and apparently truncated, with its short process covered with granulations. The incus seems to be lost and the stapes is exposed to view, covered by an almost invisible membrane through which its dimpled head shows perfectly. The promontory is rough, and there is a red streak posteriorly of uncertain nature.

When the ossicular chain is broken, as by loss of the incus or its shank, any remains of the damaged larger ossicles are of interest only as possible maintainers of suppuration, and if not soon brought to healing should be removed; but when the chain is unbroken, more can generally be accomplished for the improvement of the hearing by judicious mobilization and massage than by excision. Adhesions, after being cut, often unite more firmly than before; but the blunt probe may stretch them so as to afford lasting relief. When the dimpled head of the stapes comes to view (Fig. 1750) we know that the incus is disarticulated, if not lost, and we should confine our intervention to freeing the oval and round windows.

B. Alexander Randall.

EAR DISEASES: ARTIFICIAL AIDS TO DEFECTIVE HEARING.

—When, in the course of disease, either of the sound-conducting or of the the sound-perceiving apparatus, pathological changes have become so pronounced as to render ordinary conversation, or even that of a higher pitch, unintelligible to the unfortunate individual, and when all of the well-recognized methods of treatment have proven unavailing, then it may become necessary, for his comfort and convenience, and that of his friends as well, to resort to the adaptation of one of the mechanical devices which experience has shown to be useful in such conditions.

For convenience of description these appliances may be divided into three classes:

1st. Those for use within the auditory canal and tympanic cavity and which are concealed from view, or nearly so.

2d. Those in which the bulk of the instrument is exposed to view and the sound waves are transmitted by means of a conveniently shaped tip introduced into the meatus.

3d. Instruments which are brought into use by simply placing the proximal end against the auricle and the distal end in the direction from which the sound waves emanate.

The ideal instrument in all respects, did it but sufficiently contribute to the augmentation of the sound waves, would be one of the first class, for they are of necessity very small, being limited in size to the diameter of the meatus and auditory canal, and hence could be worn unobservedly. But, unfortunately, they can aid only by affording support to the remnant of drum membrane which may be present or to the ossicles, and by directing or concentrating upon the sound-perceiving apparatus such aerial vibrations as are collected by the auricle for transmission into the meatus. Could a small instrument be devised that would render the same service as one of the larger kind later to be described, the ideal would be reached. The problem has not yet been solved and will not be easily.

Marcus Banzer (1640) suggested the introduction into the auditory canal of an ivory tube, over the end of which was stretched a portion of pig's bladder. Leischevin (1763), Antereith (1815), and Lincke (1840) used similar devices in cases of perforation of the drumhead, but seemingly with the only object in view of protecting the exposed delicate structure of the tympanic cavity, as we have no account of any attempt on their part to improve the hearing. It is well known to those familiar with otological literature that the first account of a device worn within the ear, for the purpose of improving the hearing, was recorded by Dr. Yearsley, of London, in 1848. He was informed by a patient from this country who consulted him that he could, by placing a rolled strip of paper in the auditory canal, markedly improve his hearing. Tests made at the time proved the statement to be true beyond question.

Dr. Yearsley was quick to take advantage of the discovery, and subsequent experimentation led him to substitute pellets of cotton for the twisted paper, since frequent trials of the latter had invariably failed on other patients.

Toynbee in 1853 introduced his artificial tympanic membrane (Fig. 1751), which consists of a disc of vulcanized rubber of the size and thickness of the normal membrane, and to the centre of which is attached a wire about an inch in length, terminating in a little ring to enable the thumb and finger more readily to grasp it for the purpose of introduction and removal. Modifications of the original membrane of Toynbee are numerous, and, as sold in the shops of to-day, it consists of a thin circular disc of india-rubber tissue, to the centre of which is attached a gold wire. Politzer invented for use among the poor an artificial membrana tympani, the manufacture of which is, as he states, very simple. A piece is cut from the side of an india-rubber tube 2 to 3 mm. thick, and to the lower end of this is fixed a strong piece of wire as indicated in Fig. 1752.

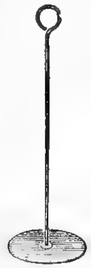


FIG. 1751.- Toynbee's Artificial Drum Membrane.

Gruber, on account of the liability of the Toynbee disc to become detached from the wire, the conspicuousness of the latter when in position in the canal, and the liability of the deeper parts to be injured if a blow should fall upon the ear, substituted for the wire a thread passed through the centre of the disc, and then provided for its introduction by specially devising for the purpose an instrument which is nothing more than a wire with a small ring at its end and bent at right angles to the shaft. The thread is passed through the ring, and then, after the disc has been introduced, the wire is removed, and the thread is left lying in the canal with one end protruding from the meatus—an arrangement which renders it easy for either the surgeon or the patient to remove the disc. A small piece of soft lint has been used instead of the india-rubber. Again, an india-rubber tube, cemented at the end to the disc, has been employed instead of the wire.

It matters not whether the original Toynbee drum or one of its modifications be used, it will be found advantageous to moisten it before introduction, either with warm water, an antiseptic solution, or vaseline, to cut and trim it until the desired size is secured, and, finally, to change its position until the right spot has been found, and the improvement in hearing—if in any way attainable—has been obtained. Frequent changes are often found to be necessary before the contrivance can be worn comfortably by the patient, while at the same time rendering efficient service. If the use of this device improves the hearing, the patient can readily be taught to introduce and remove it, and soon he becomes so expert as to be better able to judge when it is in the proper position than the surgeon.

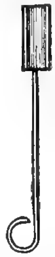


FIG. 1752.—Politzer's Modification of Toynbee's Artificial Membrana Tympani.

The Yearsley pellet of cotton (Fig. 1753), is probably more often used at the present day than any other intra-aural device, and, as stated by Dr. Thomas Barr, it has the following advantages over Toynbee's artificial membrane: "(1st) It is softer and excites less irritation; (2d) it is a convenient medium for applying medicaments to the interior of the ear; (3) it does not cause disagreeable noises when the wearer is chewing, as does the wire of Toynbee's membrane; (4) it has the advantage of being entirely concealed." Its cheapness and convenience certainly recommend it in clinical practice, and it is doubtful if the disc would be useful where the cotton pellet fails.

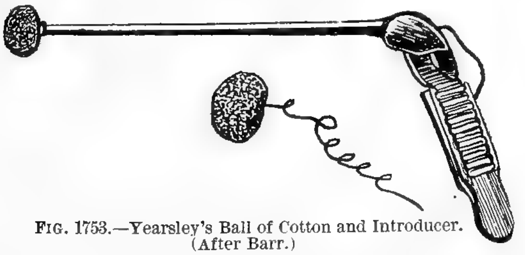


FIG. 1753.—Yearsley's Ball of Cotton and Introducer. (After Barr.)

While the cotton pellet may be used dry, better results will be obtained by moistening with glycerin, or with a suitable antiseptic, if suppuration still exists. The cotton is easily introduced with a delicate forceps or by an instrument such as is shown in Fig. 1753, or by one made for the patient's use, like that shown in Fig. 1754.

The method which should be followed by the patient in introducing the cotton pellet is so well shown in Fig. 1755 that no further explanation is needed. The piece of thread which is attached to the ball of cotton and which lies in the canal, enables the patient to remove it at his pleasure.

Hassenstein's device consists of a small hard-rubber stem (split throughout a part of its length and provided with a sliding metal ring) which holds the cotton plug firmly and is intended to remain with the plug in the canal. Hartmann recommends as a substitute for an artificial membrane a small thin rod of whalebone enveloped by cotton wool. Leichtenberg suggested the application of flexible collodion to cover over the perforation in the membrane. Blake has had marked success in some cases by the application of sized paper to the perforation in the membrana tympani. This not only enables the patient to hear better, but contributes as well to the permanent healing of the opening. Gruber states that he has tried various materials for use as an artificial membrane and that those made from linen or silk, as suggested by Czarda, sometimes accomplish more than the others.

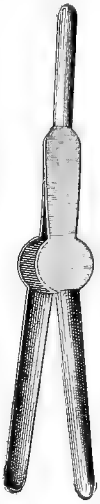


FIG. 1754.—Forceps for Patients to Use in Introducing Cotton Pellets into the Ear. (After Barr.)

In all of these devices, it matters not which may be used, success depends upon so placing the appliance as to induce pressure on the stapes or the long process of the incus, and as a rule the proper location can be found only by repeated trials. In rare instances it is possible to improve defective hearing by means of one of these devices when the drum membrane is intact, but it is only in those cases in which continuity of the ossicular chain has been broken, or in those in which extreme relaxation of the parts exists, that we can hope, by making pressure against the manubrium mallei or against the stapes, appreciably to improve the hearing.

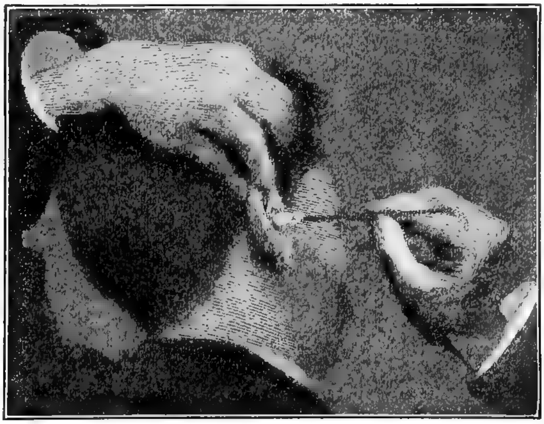


FIG. 1755.—Patient Introducing Disc of Cotton into his Own Ear. (From Barr.)

When there is acute inflammation in the ear, or when there is profuse suppuration, or when the wearing of the artificial drum causes tinnitus and vertigo, or when the patient has one good ear, no attempt should be made to use an artificial membrane. Neither should it ever be forgotten that where the tympanic cavity is the seat of a chronic suppuration, be the otorrhœa ever so slight in quantity, the necrotic process is liable at any time to extend to the mastoid antrum and cells, or through the tegmen antri to the dura. The mere matter of improving the hearing sinks into insignificance in the presence of the danger which constantly menaces the patient.

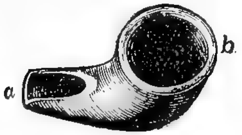


FIG. 1756. — Politzer's Metallic Horn, to be Worn as an Aid to Defective Hearing. *a*, End which is to be introduced into the orifice of the external auditory canal; *b*, larger flaring end which is to be directed toward the hollow of the concha.

It is needless to say that the canal and the device, whatever it may be, should be rendered aseptic before the latter is introduced, and the appliance should be changed as often as need be to keep the parts in a perfectly healthy condition. Such precautions should be taken as to not induce suppuration where none already exists. The appliance should be worn but a short time at first, and the periods should be gradually increased from day to day until the instrument ceases to cause any discomfort, and even then it is best to remove it on retiring for the night.

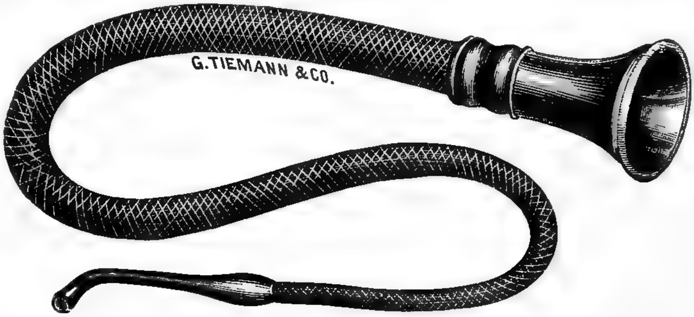

G.TIEMANN &CO.

FIG. 1757.—Currier's Conico-Cylindrical Tube.

We now come to the second class of appliances — those designed so to collect the sound waves as to enable the very deaf to hear, or those moderately deaf to hear at a greater distance. The proximal end of the instrument is, by means of a conveniently shaped tip, introduced into the meatus. Small devices, which are sufficiently small to escape notice, and yet which possess the power to increase one's hearing power, are being constantly sought for by persons who, while deaf, are naturally anxious to conceal their infirmity. Many of them are on the market, but as a rule they are worthless, except where the defect in hearing is due to collapse of the walls of the canal, which is a rare condition and seen only, so far as I know, in very old people.

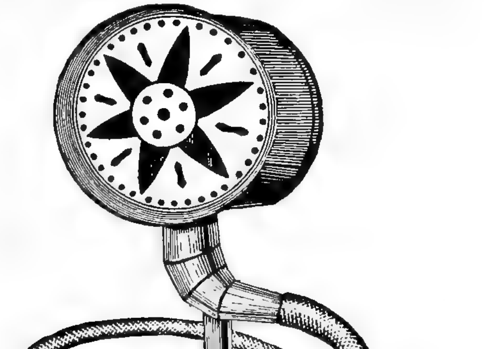


FIG. 1758.—Ear of Dionysius.

Politzer has introduced an instrument the shape of a hunting horn (Fig. 1756), and about an inch in length. The narrow end is introduced into the meatus and the mouth directed to the hollow of the concha. The object of this instrument is to increase the normal effect of the inner surface of the tragus in reflecting the waves of sound coming from the concha into the external canal. Politzer noted improvement in three-fourths of his cases from the use of this instrument. Other surgeons have not met with the same degree of success.

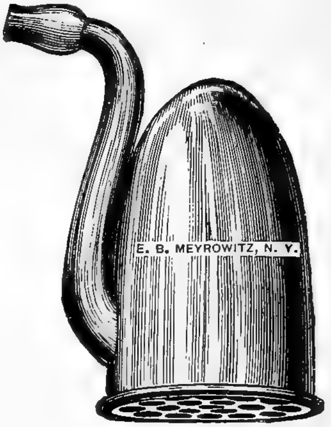

E. B. MEYROWITZ, N. Y.

FIG. 1759.—The London Hearing Dome.

For use in hearing a person speak at only a short distance, the best instrument of this class is probably Currier's conico-cylindrical tube (Fig. 1757). This instrument, which is often termed a "conversation-tube," consists of a tube three and one-half feet long, which has a bone or hard-rubber tip at one end, while the other end is a bell-shaped mouthpiece made of the same material. The tip and mouthpiece are connected by an elastic spiral wire tube covered with rubber and over-spun with either silk or mohair. The tube is conical, thus forming a gradually decreasing channel from the mouthpiece to the ear. The lips should be placed close to the mouthpiece, and the speaker should at first modulate his voice, as loud tones are often very distressing to the listener. It may be worn around the neck under the coat or cloak or rolled up and carried in the pocket. It is use

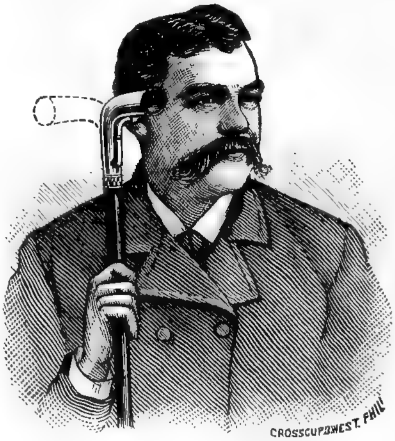

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FIG. 1760.—Acoustic Cane.

less for listening to a public speaker or for general conversation. The best appliances for this purpose are the ear trumpets. They are more efficient for general use owing to the greater diameter of the bell-shaped mouthpiece. The larger the size and the greater the length of the conical tube the more powerful is their sound-conveying capacity. An instrument not designed to carry about is such an one as is represented in Fig. 1758, which may be placed on a stand or any convenient place and is useful in listening to general conversation.

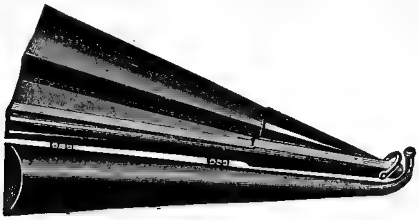

FIG. 1761.—Folding Fan Ear Trumpet.

The London hearing dome answers in many instances remarkably well for those who are moderately deaf. It can be easily carried in the pocket and is concealed in the hand when in use. It consists of a small cup-shaped bowl, provided with a mechanism peculiarly adapted for sound-wave concentration and conduction. A perforated diaphragm over the mouth of the trumpet admits the sound waves, while a curved tube, extending from the base of the bowl, conducts them to the ear. This is shown in Fig. 1759.

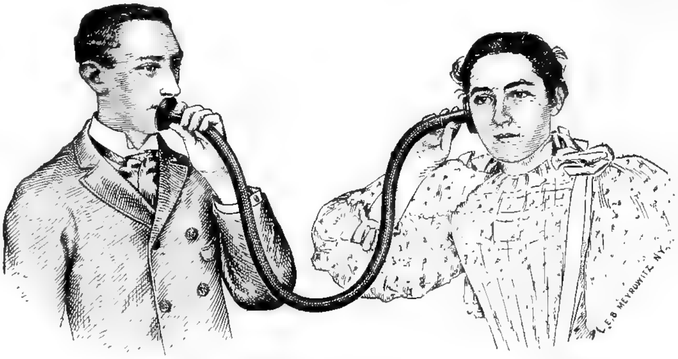
E.B. MEYROWITZ N.Y.

FIG. 1762.—The Otophone. (No. 1.)

The acoustic cane (Fig. 1760) consists of a walking stick with a conical, curved, hollow metal handle, open at the end to receive the sound waves, and an ear tube at the side below the handle. It is convenient for gentlemen's use.

The fan ear trumpet (Fig. 1761), answers a like purpose as an aid for ladies. It consists of a folding fan of black silk, one side of which is formed into a trumpet with an ear tip at the handle, making an appliance which can be carried and used without attracting much attention.

All these appliances, together with many others similar in construction, which have not been referred to, have a conical-shaped tip for introduction into the meatus and canal. They are liable to cause irritation and sometimes furuncles. Again, in many instances, the unnatural augmentation of sound and the reverberations are confusing and distressing to the individual.

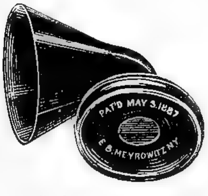

FIG. 1763.—The Otophone. (No. 2.)

The third class of instruments are of a newer type and to a marked degree have overcome the objections named in connection with the others. They do not permit the column of air to strike against the drum membrane. The sound waves are intercepted by means of a diaphragm, and it is claimed for them that they transmit only proper voice tones. The instrument is placed against the auricle, thus avoiding all danger of irritation to the meatus. The best appliance of this type for near conversation is probably the otophone (Fig. 1762), which consists, as described by Dr. Charles H. Burnett, of Philadelphia, "of a flexible tube, three and one-half feet long and one inch in diameter, with a mouthpiece of convenient arrangement for the speaker. The aural end has the great advantage and comfort of terminating in a disc, resembling the receiver of a telephone, which is held to the ear. By an arrangement of diaphragm in this earpiece of the otophone the disagreeable resonance prominent in the entirely open instrument is prevented, and it seems to convey sound to the deaf more completely than any other instrument as yet offered."

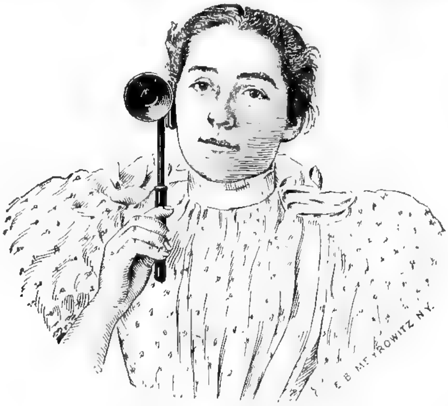
E.B. MEYROWITZ N.Y.

FIG. 1764.—Otophone with Handle.

The otophone No. 2 (Fig. 1763) is made in three sizes, and this style of instrument is particularly adapted for church, concerts, lectures, and general conversation. Its use for such purposes may be rendered more convenient by the application of a handle such as is used in connection with opera glasses, and as is shown in Fig. 1764.

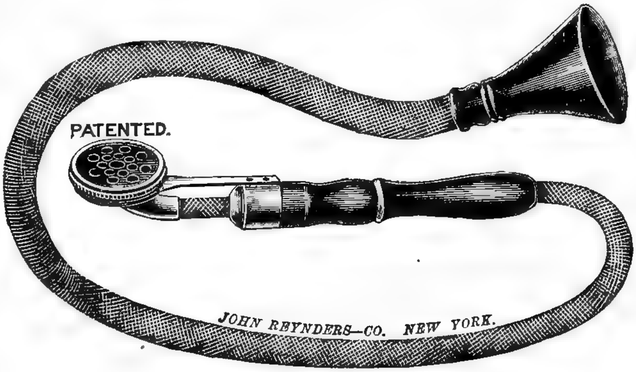

FIG. 1765.—The Audiclare.

Another instrument similar to the otophone first described is the audiclare (Fig. 1765), which provides a protection for the diaphragm, so that the earpiece can be pressed tightly against the auricle without in any way interfering with its vibrations. The spring connection between the disc and handle gives to the user control over the matter of degree of contact. If the patient is very deaf the diaphragm should be pressed firmly against the ear. Another form of this instrument is useful for hearing at a distance and for general conversation.

The Rhodes audiphone (Fig. 1766), which does not come under my classification, is an appliance made of a thin plate of vulcanite which is shaped like a fan and by means of a cord may be bent to any degree of curvature. The upper margin is placed against the upper teeth and the instrument is held with convexity forward. In this invention a large convex surface is provided for the reception of waves of sound, and these are transmitted first to the teeth, and thence through the bones of the skull to the labyrinthine fluid and the auditory nerve independently of the normal sound-conducting apparatus. This instrument is very limited in its conducting property; hence waves of sound with no greater intensity than those of the human voice can affect it but slightly, and on account thereof it has proved disappointing in most instances.

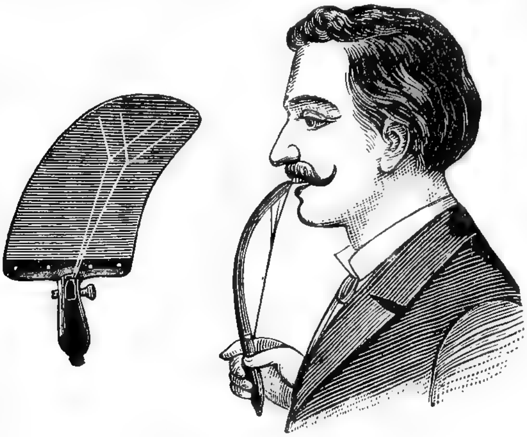

Fig. 1766.—The Rhodes Audiphone.

The Akouphone, which has recently come into use, is perhaps attracting more attention than any instrument yet devised. It is the invention of Mr. M. R. Hutchinson, an electrical engineer, and is seemingly the best aid to defective hearing yet discovered. A most satisfactory demonstration of its usefulness was recently made before the Otological Section of the New York Academy of Medicine. The instrument consists of a receiver, an ear-piece, a dry pocket storage battery, and a small flexible cord connecting the parts together. The ear-piece is adjustable at will to conform to the degree of deafness of the person and the intensity of sound desired. The pocket storage battery can be easily recharged from any direct electric light current. Mr. Hutchinson also manufactures a desk and opera outfit to meet the indications which the names imply.

Numerous appliances which have not been referred to, both of foreign and domestic manufacture, might with advantage be brought within the scope of this article. It seems best, however, to limit description to those which experience has proven to be the best. In any given case we should try many of them and not be content until the one is found which proves to be most beneficial. The improvement in hearing which may be temporarily secured from the use of these instruments, in cases in which the function of the auditory nerve has not been destroyed, is very often indeed most gratifying to the individual, and the relief afforded his friends is by no means an unimportant consideration. Where acute inflammation exists they are never to be used. In chronic ear affections, they should be used at a sufficiently early stage to furnish the necessary stimulus to the nerve, which is tending toward atrophy owing to the absence of its normal vibration. *Franklin M. Stephens.*

EAR DISEASES: CHRONIC CATARRHAL OR NON-PURULENT INFLAMMATION OF THE MIDDLE EAR.

—Etiology.—In considering the etiology of the process which is usually treated in the text books under the title of chronic catarrhal inflammation of the middle ear, it is necessary to recognize two separate and distinct processes: one in which the thickening process is tubal in its origin, whether in consequence of nasal trouble or the result of some other pathological process; and a second in which the process begins primarily at the base plate of the stapes (primary periostitis of the labyrinthine capsule: Politzer) and is for a long time confined to that region, later extending to the internal ear and also to the other middle-ear structures.

The first series of cases are usually nasal or post-nasal in their origin, although such nasal trouble need not necessarily be organic. In these patients the first process is an acute secretory middle-ear catarrh which is neglected by the patient and which passes off leaving a certain amount of middle-ear thickening to be increased by the next attack until the resulting deafness becomes perceptible to the patient and his friends. Of all diseases, adenoid disease in the naso-pharynx unquestionably causes the greatest number of chronic middle-ear thickenings,—many of which never receive treatment until the patient reaches adult life. Next to this, acute or chronic hypertrophy of the turbinates, spurs on the nasal septum, and any process interfering with nasal respiration, have an important bearing on the etiology. The prominent part formerly assigned to disease of the faucial tonsils and of the naso-pharynx (other than adenoid) was undoubtedly a mistake.

In many persons a head cold has a decided tendency to produce an acute catarrhal middle-ear trouble and to repeat this process with each succeeding cold. Often the entire deafness can be definitely traced to a simple acute rhinitis where the ear complication was at the time dismissed with the too common remark that "it would improve as the cold grew better."

Many of the acute infectious diseases, although more frequently causing acute suppurative processes, often start a chronic catarrhal middle-ear trouble. Especially where both ears are simultaneously affected,—the one with an acute inflammatory process, the other with an acute catarrhal process,—the pain of the former is apt to cause the patient completely to overlook the existence of the latter. When the catarrhal process occurs as a complication of influenza or of typhoid it is apt to be disregarded, while, on the other hand, a painful ear disease would, under these circumstances, be at once recognized.

Infections of the middle ear are apt to terminate in a chronic catarrhal process; this being especially likely to occur in influenza, typhoid, and measles.

A large number of middle-ear thickenings come from certain constitutional diseases, particularly rheumatism, gout, and syphilis.

Certain occupations are important factors: those in which the patient is exposed to draughts, dust, or other conditions tending to cause an acute rhinitis; and those in which the ear is subjected to the jar of loud sounds, particularly boiler working, nail making, the shuttle rooms in mills, etc. Also the constant use of the telephone certainly plays the part of a cause in a number of cases. It has been the writer's experience that where the ear is healthy when the patient enters an occupation such as that of a telephone operator or a mill operative, no trouble will be experienced, but this is not true of boiler making and nail working.

Those cases in which the disease process begins primarily in the neighborhood of the stapes base plate are rarely tubal in origin and not catarrhal in nature. The process is apparently a vaso-motor one in many instances and often a sequel of neurasthenia. In many individuals it is clearly hereditary. In other cases syphilis, gout, and rheumatism are prominent factors, as are also debilitating diseases or severe anæmias.

PATHOLOGY.—The pathological conditions found in chronic catarrhal middle-ear disease are either local—*i.e.*, confined to the neighborhood of the stapedo-vestibular articulation—or diffuse throughout the middle ear, according to the type of disease present. In the first form, the Eustachian tube, mastoid process, and membrana tympani are unaffected. The stapes may be fixed by a union of the base plate only or by union of the crura to one or more sides of the fenestra ovalis, or the rigidity may be due to a general membranous or bony fixation, the latter often in extreme cases projecting into the vestibule and cochlea. The pathological lesion here was well understood and studied very early by Toynbee and carefully described by him, but his observations seem to have been too long neglected. In an examination of 1,149 cases he found 53 in which there was a membranous ankylosis of the base plate of the stapes without any enlargement of the base or of the articular surface. In 49 cases there was ankylosis from enlargement of the base plate with no alteration of the structure. Twenty-nine cases showed an osteoma of the base of the stapes, hypertrophy of the normal bone tissue, firm ankylosis, and the enlarged base plate projected into the cavity of the vestibule. New bony tissue beyond the limit of the oval window was found in 35 cases. In 4 cases there was firm adherence to the inferior portion of the oval window, and in 13 cases the entire circumference was ankylosed. In 12 cases the circumference and vestibular surface were affected and the rest of the stirrup was normal.

In the second form of chronic middle-ear catarrh we may find the stapes ankylosed, but such ankylosis is associated with other pathological changes in the tympanum. Often the fenestra rotunda is filled with connective tissue and greatly thickened; some cases of calcification at this point have been reported; at other times the tympanic mucous membrane over the oval window is greatly thickened. Ankylosis of the malleo-incudal articulation is occasionally seen, but that of the incudo-stapedial joint is rare—Toynbee reports only two cases in his 1,149 dissections.

In beginning cases the mucous membrane of the tympanum is swollen and infiltrated, so that the depressions in the attic, the round and oval windows, and the promontory are obliterated and the normal mucous membrane folds are much swollen. At a later stage organization takes place, the mucous membrane is much thicker than normal, and the folds of the tympanum as well as the capsules of the joints of the ossicles are consequently much more rigid.

Similar alterations take place in the Eustachian tube so that the lumen is narrowed by the swelling of the mucous membrane, but actual stricture is rare. Secondary changes take place in the intratympanic muscles, largely from their disuse; they become degenerated or atrophied. From the swelling of the mucous membrane of its inner coat, the membrana tympani becomes less and less transparent and thicker, either in whole or in part.

SYMPTOMATOLOGY.—The onset of this disease is so gradual and the preliminary symptoms are so slight that usually several years elapse before the patient presents himself for treatment. His friends have assured him for some time that he was "becoming absent-minded," and he himself has probably noticed a slight tinnitus, possibly at first only with an acute rhinitis, but later constant. For many years, in slowly progressive cases, the deafness and tinnitus remain the only subjective evidence of trouble. Then, as the stapes and the membrane of the round window become more rigid, the patient begins to have, with a marked increase of these symptoms, auditory vertigo and nausea. The latter symptoms are much more common in ear disease, and especially this particular form of ear disease, than is ordinarily supposed, and it is the experience of every aurist that the correct diagnosis is not made until the patient has been put through a long course of stomach treatment.

The amount of vertigo varies very much, but in the middle-ear cases it is usually of a mild type and not apoplectiform in character, but instances of this are occasionally seen. It varies directly with the amount of thickening about the stapes and within the labyrinth, and with the general condition of the patient. He may stagger when he walks, as if drunk, or in the apoplectiform type he may fall to the ground so suddenly as to injure himself. The vertigo is usually worse in the dark and continues when the eyes are closed. In some cases the attack wakes the patient from his sleep. Pure aural vertigo is, however, never accompanied by unconsciousness or local paralysis.

The amount of nausea and vomiting is as a rule dependent on the amount of vertigo and is independent of indiscretions in diet. With some the vomiting is persistent for four or five days and requires rectal feeding.

In many cases of chronic middle-ear catarrh the patient complains of a dull, heavy pain in the depth of the ear; acute pain is, however, never caused by the disease.

In the beginning stage there is apt to be an over-accumulation of cerumen, so that once in six or eight months a large mass blocks the canal and has to be removed. In the later stages of chronic middle-ear thickening the reverse is true,—little or no wax forms, the canal is dry and glistening, and the resultant itching from the dryness of the canal is often very annoying to the patient.

It was long ago noticed that many of these patients possess the ability to hear better in a noise than persons with normal hearing (paracusis—Willis), and this often leads those engaged in noisy occupations to disregard their deafness until it has reached a high degree.

A more annoying symptom which is occasionally noticed, especially in neurotic people, is a hyperæsthesia to tones either of a certain pitch, usually high, or of a certain loudness. This presumably arises from the unnatural tension of the auditory mechanism and will be found very difficult to treat successfully.

When the membrana tympani is relaxed, and also in some cases from the simple increase of intratympanic pressure, the patient is annoyed by a sharping or flatting of tones in the affected ear, producing a discord when a simple musical tone is sounded. This symptom is probably present in many cases, but is observed only when the patient has a knowledge of music. The middle and upper registers are most often affected. A variation of this symptom is seen in some persons when a jarring sound is heard in the ear whenever a certain note is struck.

In the beginning stages of middle-ear thickening autophony is often complained of. Either the patient's own voice or the sound of his footsteps, or outside sounds, echo in the ear as if a resonator were held to the auricle. Of all the annoyances to which this type of ear disease subjects one, the tinnitus is usually the most wearing. All sorts and varieties of sounds are heard in most cases—either vascular or from spasmodic action of the intratympanic or pharyngeal muscles; hence we have clicking, buzzing, beating, roaring, or singing sounds. In the cases of stapes fixation a very characteristic symptom, often noted one or two years before any other, is a continuous high-pitched tinnitus like escaping steam or the sound of the fields in August. All these varieties of sounds are of course dependent upon the circulation and general condition and are apt to increase when certain drugs are ingested or when certain positions of the body are assumed. Thus, for example, a beating tinnitus is usually increased by alcohol or by bending forward or lying down. As elsewhere stated, the rarefaction of air obtained at an altitude of over one-thousand feet will modify many cases decidedly.

Both the tinnitus and the deafness are apt to be worse in damp weather, and at such times the patient also notices a feeling as if the tympanum were filled with wool. Bodily fatigue also influences both symptoms to a marked degree.

DIAGNOSIS.—The diagnosis of this affection is made by the objective examination of the ear combined with a functional examination. In the cases in which the process starts in the fenestra ovalis, we may expect to find no pathological change in the membrana tympani, except that in some rare cases a reddish glow is seen instead of the normal yellowish reflex from the mucous membrane of the tympanic cavity. This congestion may cover the whole inner wall of the tympanum or be confined to the region of the oval and round windows.

When the process is tubal in its origin we get immediate objective changes. The membrane is retracted, the short process of the malleus more prominent, and the manubrium less so, being pulled backward and upward and foreshortened. When the retraction is extreme, especially in children, a band extending nearly horizontally from the short process of the malleus to the periphery of the membrane is put on the stretch and made more prominent. The color of the membrana tympani is much altered, being whiter than normal, and there is of course a more or less complete loss of transparency from the increase in thickness of the mucous layer of the drum membrane. Except where some acute process is present, the lustre of the membrana tympani is either unaffected or increased in brilliancy.

The functional examination is the more important of the two in all forms of middle-ear thickening, and should always be made with instruments giving tones of several different pitches. In even a routine examination at least the amount of deafness for spoken words, the results obtainable by the Rinné test with a fork of the middle register, and the upper and lower tone limits should be ascertained before an intelligent opinion can be given.

As a general rule it may be said that the more fixed the stapes becomes in the oval window and the more rigid are the membrana tympani and the ossicular chain, the greater the loss for air conduction of bass tones. At the same time there will be a diminution of air conduction for all tones, this being more marked the lower the pitch of the tuning-fork used; the hearing by bone conduction will also be found to be either unaltered or increased. If the labyrinth is unaffected, the hearing for high tones will be unaltered even where the deafness for tones of the middle or low register is very pronounced.

As a matter of practical experience, it will be often found that in cases of thickening and rigidity of the membrana tympani alone, or of this membrane and the malleo-incudal and incudo-stapedial articulations, the amount of deafness for the watch will be proportionally greater than for other tones, whereas in the primary stapes fixations the hearing for the watch is better than for other tones and the bass-tone hearing is the most affected.

In all testing allowance must be made for the intelligence of the patient, and the test should be made in a quiet room, for the reason that many of these patients hear much better in a noise. One should also be careful not to allow the patient to see the lips in testing with spoken words, as such patients are often proficient lip readers.

Prognosis.—Chronic middle-ear catarrh has always been considered the opprobrium of aural surgery, and certainly the prognosis of this disease in the past has often been given too hastily and with too little regard to the etiology and the general condition of the patient.

The prognosis of those cases in which the middle-ear thickening is confined to the membrana tympani alone, or to this membrane and the malleo-incudal and incudo-stapedial articulations, is usually much more hopeful than where the process starts in the stapedo-vestibular articulation. In all cases in which the chronic middle-ear catarrh is the result of a general disease process, as for instance gout or rheumatism, the prognosis must, of course, depend upon that of the causative disease.

As a general rule, all cases in which the tuning-fork reaction in the Rinné test shows the bone-conduction hearing a great deal prolonged over the normal, and especially in those cases in which the air conduction is lost for forks of 512 v. s. or over, the chance of any restoration of hearing is very small. Much depends upon the duration of the disease; and owing to the fact that the onset is in the great majority of cases slow and insidious, the treatment is apt to be begun long after the middle-ear thickening has become far advanced. It should, however, never be forgotten that the disease left to itself naturally tends to increase year by year, and it is as much the duty of the physician to arrest its progress as to relieve what deafness has already become the fate of the patient.

The tinnitus is often as annoying or even more annoying to the patient than the deafness and requires as careful consideration in the prognosis of any individual case. In brief, it may be said that any symptomatic treatment of this symptom by drugs—such, for example, as the bromide—will prove an utter failure except to tide the patient over a temporary increase of the trouble. Treatment of this symptom should be with reference to the pathology of the disease, and no symptom will be found more dependent upon the patient's general health than this.

Many patients with middle-ear thickening are troubled with a certain amount of vertigo and often also nausea—symptoms which increase in proportion as the rigidity of the ossicular chain increases, and which are decidedly more common in neurotic individuals than in those who show no such predisposition. Here we may hope to effect some improvement by the administration of drugs, especially those which act on the circulatory system; but we should again remember that the vertigo is a symptom of a disease and that it is our chief duty to consider its causation in our treatment.

Especially in the primary stapes fixations, we may consider the prognosis worse when there is a history of hereditary deafness. When the chronic middle-ear thickening clearly results from nasal or post-nasal trouble and is worse after colds, much can be done in checking the progress of the disease; but certainly far too hopeful a prognosis has often been given in these cases, for it is manifestly impossible for any nasal or post-nasal operation to improve a case of middle-ear trouble where there is ankylosis of the ossicular chain, and especially of the stapedo-vestibular articulation, and where the air conduction for bass tones has been markedly diminished for any length of time.

When the disease process is owing to syphilis or to myxœdema, and has not been of too long duration, much improvement can be obtained by appropriate treatment even when the deafness is of a high grade.

Treatment.—Treatment of this disease may be divided into two great classes, local and general. Considering general treatment first, we find that a very large number of cases are nasal or post-nasal in their origin, and such must receive appropriate local treatment before any permanent improvement can be attained. A large number also are secondary to some disease, particularly gout, rheumatism, and syphilis, or originate during some acute disease, such as influenza, typhoid, or pneumonia. Furthermore, middle-ear thickenings of whatever cause are always much influenced by an intercurrent neurasthenia or anæmia. The treatment in these cases is, of course, plain.

So commonly is the syphilitic element present in middle-ear thickening that the author believes that iodide of potassium and pilocarpine should always be tried before a case is abandoned as hopeless. The disease process here is, as a rule, a tertiary manifestation. Pilocarpine hydrochlorate, in doses of gr. $\frac{1}{8}$ to $\frac{1}{4}$ once or twice a day, is often of very great benefit to such patients, especially when given subcutaneously; but as a rule it is of only temporary value, unless given in conjunction with iodide of potassium or mercury.

In the deafness which develops in the course of myxœdema much may be expected from the use of thyroid extract, but it has been the author's experience that no improvement is to be expected from this drug in any other class of middle-ear catarrh, although many claims have been made for it, especially in cases of primary stapes fixation.

For the relief of tinnitus aurium and vertigo a formidable list of drugs has been advocated by various authors, and a careful consideration of the individual case must always be made in the selection of treatment. Iron and arsenic will of course benefit the anæmic case, and anæmia will be found to be a factor in a very large proportion. The bromides will often, at least temporarily, benefit the neurotic patient. In such cases as are circulatory in their origin, digitalis, nitroglycerin, or strychnine will be found of benefit. Small doses of quinine, gr. $\frac{1}{10}$ to 1 every three hours, have been strongly advocated for the relief of vertigo, especially by the French writers, but the author has found that very little improvement follows such treatment. In an occasional case some improvement may be obtained from the use of other drugs frequently mentioned for the relief of tinnitus—as, for example, gelsemium, hydrobromic acid, etc. Particularly in the nasal, rheumatic, and gouty cases climatic conditions may have an influence, and much may be gained if the patient is able to make a change of surroundings. When the tinnitus has been due to an increased intralabyrinthine pressure from indrawing of the drum membrane and locking of the ossicular chain, much temporary improvement may be secured by residence at an altitude of one thousand feet or over.

Repeated head colds being a very common cause of this disease, much benefit may be derived from fresh air and exercise, proper clothing, and other measures designed to prevent the recurrence of the acute rhinitis.

Local Treatment.—Pre-eminent in local treatment stands inflation of the middle ear by the Eustachian catheter or by means of the Politzer bag, but there is no doubt that in the past this treatment has been adopted too indiscriminately and that much harm has been done thereby.

The Eustachian catheter should be used in preference to Politzerization in all cases in which its use is possible, as in this way the amount of intratympanic pressure can be much better gauged. Also it is possible by this mode of inflation to treat one ear independently of the other. In children and old people the Politzer bag must usually be employed. Care must be taken not to inflate too vigorously or too frequently, and in all cases treatment should be abandoned when the drum membrane shows signs of overstretching, as indicated by an abnormal light reflex in the upper posterior part of the membrane. The Valsalvan inflation is very little used at present and is of doubtful benefit, if not of positive harm, to the average patient. By many aurists the middle ear is inflated by means of a compressed air apparatus instead of a Politzer bag; in this case the pressure should not exceed fifty pounds to the inch.

The Eustachian bougie was formerly much used, and at the present time Eustachian electrolysis is having some vogue; both are based on an insufficient study of the pathology of the disease, as actual stenosis of the Eustachian tube is comparatively rare.

Occasionally the Eustachian catheter is used for injecting fluids or vapors into the middle ear; pilocarpine, menthol, muriate of ammonia, and albolene are the remedies which have been especially recommended for use in fluid form, while as vapors the fumes of iodine, chloric ether, camphor, and ammonia are generally employed. In the author's experience very little benefit, other than that due to the effect of the simple inflation of the ear, is to be derived from the employment of these drugs in this manner.

In primary stapes fixation little or no benefit can be derived from any form of middle-ear inflation, as it is obvious that such a process does not start in the Eustachian tube. Here some form of aural massage, such as the tragus pressure of Hommell, or one of the various methods of instrumental massage—*e.g.*, that by means of the Siegle speculum, or the Delstanche masseur, or Lucæ's pressure probe, or that which is based upon the employment of some form of musical tone vibration—may be of some service. Undoubtedly the simple Siegle or the Delstanche instrument is vastly preferable to their electric prototypes, and by their use an occasional improvement as to tinnitus may be obtained; but there is a great risk of stretching the membrana tympani. The Lucæ pressure probe also relieves an occasional tinnitus aurium, but is usually unsatisfactory in its results. All the different forms of musical massage now on the market are unscientific in principle and either productive of no benefit or positively deleterious to the patient.

In this form of the disease much more is to be expected from general than from local treatment, and a careful consideration of the etiology of a given case will usually give a clew to the best treatment to adopt.

Where a patient with tinnitus presents one spot on the membrana tympani which is thinner than the rest of the membrane, relief may occasionally be obtained by covering this place with a very thin piece of rice paper or with the vitelline membrane of the egg. The paper in such cases must be highly sized and thin, and must be made to adhere by moistening it with water. Where relief is obtained by its use the tinnitus will return when the paper works off the thin spot over which it has been placed, *i.e.*, usually at the end of about eight or ten weeks. The egg film is best moistened in the egg albumen, and will then remain in place for about the same length of time as the paper patch.

Where from treatment or otherwise the membrana tympani has become stretched, the patient will complain of a flatting or sharping of tones. Such cases may nearly always be relieved by placing a paper or egg-film patch over the stretched portion of the membrane, but in some cases it may be necessary to place several layers one above the other. The same result is obtained by painting the flaccid portion with contractile collodion.

From the very beginning of otology aurists have tried by operative means to relieve the patient. Among these operations may be enumerated: making a permanent opening in the membrana tympani; tenotomy of the tensor tympani alone, or of both the tensor tympani and the stapedius; cutting the posterior fold; removing the membrana tympani, malleus and incus, or the incus alone; and, finally, excision of the membrana tympani, malleus, incus, and stapes, or of the stapes alone. All these have had more or less extravagant claims made for them, have had a vogue for a time, and then have gradually been abandoned. Unquestionably each of these measures is applicable to an occasional case and harmful to most others, but this subject will be better handled in the chapter devoted to it. (See article on *Ear Diseases: Operations upon the Tympanic Membrane and Ossicles.*)

Eugene A. Crockett.

EAR DISEASES: CHRONIC PURULENT INFLAMMATION OF THE MIDDLE EAR.

—(Synonyms: Otitis Media Purulenta Chronica; Chronic Purulent Ear Catarrh; Chronic Suppuration of the Middle Ear.)

In the present article it is to be understood that the term chronic purulent otitis media applies only to those cases in which the inflammation has lasted for a period of three months or more, with or without treatment; and that the parts involved in the inflammation are the structures which form the middle ear.

ETIOLOGY.—A chronic purulent inflammation of the middle ear may be said to develop, in all cases—with the exception, perhaps, of those which are of a tuberculous nature,—out of the acute form of purulent otitis media; and the factor which plays the most important part in conferring the characteristic of chronicity upon them is the lack of proper drainage. There are various pathological conditions which may favor such imperfect drainage. Thus, for example, the perforation in the drum membrane may be of such small size or may occupy such a position that it can drain only inadequately the cavity which lies behind it. Polypi and large granulations may form, and these may partially obstruct the escape of the discharge, while at the same time they aid in rendering it more profuse. Then, as a result of the retention of the discharge, the solid elements which it contains will accumulate in constantly increasing amount, until finally there will be lodged in the attic, or farther back in the mastoid, a cheesy substance—the so-called cholesteatomatous material. Through the agency of the bacteria of decomposition this material soon becomes foul-smelling.

Still other factors often aid in producing or in aggravating the unfavorable conditions just enumerated. For example, adhesions may form and may serve as further means of retaining the secretion in small spaces or pockets. Necrosis or caries of the ossicles or of any portion of the tympanum may take place when the disease has been prolonged for any length of time, and this is particularly apt to be the case where the disease has been confined to the attic region. In this locality the head of the malleus and also the inner portion of the superior part of the tympanic ring, upon which the head of the malleus rests, are usually found to be necrotic.

PATHOLOGY.—In chronic purulent otitis media we encounter a series of pathological pictures quite different from those observed in the acute or subacute form of the disease. The drum membrane, or what is left of it, is usually out of all semblance to its former shape and position, and whatever portion remains is so distorted from its natural shape, owing to previous involvement and the pressure exerted upon it from behind, that it looks, at first sight, like one red mass of granulation tissue, with usually a small depression—sometimes a pouting outward—at the point of exit of the discharge. If this condition be not speedily relieved, we very soon have the destructive process attacking not only the ossicles but various portions of the tympanic wall. The bony part attacked first is usually that part which has a scant supply of blood-vessels, and, as the incus is not at all bountifully supplied with blood, we usually find necrosis beginning here first. Later, the malleus becomes involved, especially that part which articulates with the incus, and, still later, the head; and if the destructive process be not arrested here, very soon erosions, exfoliations, and necrosis will develop in other parts of the tympanum, and particularly at the inner and upper surface of that portion of the tympanic ring on which rests the head of the malleus, as well as over the tympanic orifice of the Eustachian tube. Very rarely in this disease is the inner wall affected. The amount of destruction involving the drum membrane varies greatly: at one time there may be nothing more than a small perforation, and then at another time the membrane may be almost entirely destroyed. In some cases Shrapnell's membrane remains intact, but in others it also is destroyed. The perforation, in the cases in which the damage done to the middle ear is not specially great, is usually located in the posterior inferior quadrant. When the ossicular chain and other parts of the bony structure are implicated, then we find, as a rule, that the perforation is located in the posterior superior quadrant, below or on a level with the articulation of the incus and stapes, and the higher up the perforation is located in these cases the more sure are we to find intratympanic caries.

The presence of a cholesteatomatous deposit in the ear is caused by a rapid desquamation of the superficial epithelial layer of the mucous membrane, and it indicates that the drainage from the region in which the deposit is found has for a long time been inadequate—so inadequate, indeed, that the solid elements of the discharge have been retained in constantly increasing quantity. Decomposition sets in and there is then conferred upon the fluid portion of the discharge a highly acrid and irritating character which doubtless plays an important part in perpetuating and rendering more active the desquamative process. Wherever the mucous membrane is free to expand the acrid discharge excites proliferation of the connective-tissue elements—that is, granulation tissue is formed; but where the mucous membrane is under a certain amount of pressure—as in the epitympanic space and the antrum,—the irritation caused by the acrid discharge manifests itself in an active desquamative process. A very offensive odor characterizes these cases. At first, the cast-off epithelium mingles with the other solid elements of the discharge, but when these accumulate to such an extent as to form a mass of a certain degree of solidity the desquamated epithelium is cast loose in laminated sheets, oftentimes quite leathery in character. As these increase in bulk, layer by layer, they cause pressure and then give rise to a most distressing set of symptoms, to be followed later by sclerosis of the cavity in which they are formed, or they may cause absorption of adjacent bony walls, thus establishing communications between two adjacent bony cavities. When, as sometimes occurs, we find a collection of this material in a middle ear the drum membrane of which is not at that time perforated, we are warranted in concluding that the cholesteatoma developed at some earlier period in life, at which time there was doubtless a perforation of the drum membrane as also a purulent discharge from the tympanic cavity.

The complications which may arise from such a condition as I have just described—viz., mastoid disease, meningitis, infective sinus thrombosis, brain abscess, etc. —will be treated at length in other articles of this series.

SYMPTOMATOLOGY.—*Otorrhœa.*—This, which may be the only symptom present, varies greatly as to its quantity, in some cases being so profuse as completely to fill the canal and meatus, no matter how often these parts are cleansed; at other times it is present only as a dry secretion upon the walls of the canal or around the edges of the meatus. During the early stages, the discharge is rather thin, resembling yellow-colored serum, but afterward it becomes thicker, and finally changes its character to that of the purulent type.

In certain cases of this disease we find no discharge whatever, and only the history of this symptom occurring from time to time. The reason for this is easily explained if we remember that partial destruction of the drum membrane occurs in many of these cases early in life, and then at some later date cicatrization takes place, leaving a certain area of the middle ear exposed; and it is in these cases that we get the history of an intermittent discharge, caused by an acute inflammatory process travelling from the mucous membrane of the nose or naso-pharynx through the Eustachian tube, and thus starting up a similar inflammation of the membrane lining the interior of the tympanum, the results of which would naturally find their way where a minimum of resistance was present, namely, through these old openings in the drum membrane, and later appear at the meatus. The absence of any obstruction to the escape of the discharge from the middle ear would explain the absence of pain under circumstances such as I have just described. It will also readily be appreciated how much more easily in these cases, owing to the absence of a portion of its protective covering, the tympanum may become infected.

Pain.—This symptom is of exceptional occurrence. During an acute exacerbation of the disease, when there is an abundance of secretion and not enough space for its exit, the patient is likely to complain of pain. In some of the cases of long standing, particularly where destruction of the osseous tissues has taken place, there is a localized and well-defined headache on the side corresponding to that of the affected ear. This symptom is also present, in its most severe form, in those cases in which the cartilaginous part of the canal, and more particularly the base of the tragus, becomes the seat of an acute otitis circumscripta, caused by an infection from the discharge coming from the middle ear. This intercurrent affection is by no means an uncommon one, and usually takes place by reason of the patient, in his attempts to cleanse the meatus, causing an abrasion of any of these structures, thus opening a gateway for infection from the discharge which passes over these parts.

Eczema.—This develops in consequence of the irritating qualities of the discharge that appears at the orifice of the meatus. It is encountered more frequently in children than in adults, because the former are continually carrying their fingers to the affected ear, and thus causing a rapid spread of this most distressing disease. At times the eczema completely encircles the external ear, involving a goodly portion of the skin of the mastoid process and the cheek; and, when present, it is the cause of a great deal of suffering on account of the constant desire to rub the parts infected.

Facial Paralysis.—This occurs in chronic purulent otitis when a portion of the bony canal through which the facial nerve passes has become diseased, thereby exposing the nerve trunk. It may also develop without any such disease of the bone, simply through the effect of pressure exerted by inflammatory products upon a facial nerve which congenitally lacks an outer sheathing of bone.

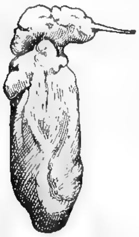
FIG. 1767.—Polypus Removed from the Right External Auditory Canal of a Man Aged Twenty-nine Years. Peduncle attached to upper and posterior wall of tympanum. (Actual size.)

Vertigo.—This may take place at any stage of the disease, but when present, it is usually associated with cases of long standing. It is caused by pressure upon the walls of the tympanum, due to the presence of fluid exudation or other inflammatory product in the tympanic cavity, or by a congestion of the labyrinth. In connection with chronic purulent inflammation of the middle ear in an aggravated form, vertigo is very frequently a symptom of some grave, intracranial complication. The symptoms which indicate the development of some labyrinthine disturbance are, briefly stated, dizziness appearing suddenly, nausea, and marked deafness, lasting for a variable length of time according to the persistency of the cause.

Fungous Growths or Polypi.—These sometimes develop from the cutaneous walls of the meatus, and doubtless they owe their existence to the fact that an irritating discharge from the middle ear constantly bathes the skin of the canal. Those which grow in the middle ear differ very much in size, some being no larger than a pinhead while others are more than an inch in length and of varying breadth. The usual size, however, is that of a pea or a small bean. In shape they differ also, some being perfectly round, while others are spherical, oblong, kidney-shaped, or lobulated, each one possessing a small, firm, fibrous peduncle, whereby it is attached to its base. Polypi, although the majority of them spring from some part of the tympanic cavity, are usually found either in the external auditory meatus or protruding from it. In some cases, however, they are entirely concealed in the vault of the tympanum. The smaller and soft ones are made up of simple granulation tissue, while many of the larger ones contain fibrous tissue alone. In the latter, the peduncle, although small, is exceedingly strong. These masses usually arise from the margin of an area of exposed or carious bone, and their usual point of attachment is in the epitympanic vault or at the upper and posterior end of the tympanum. Occasionally, however, they arise from the mucous membrane in the vicinity of a mass of decomposing material without any connection with a localized necrosis of bone.

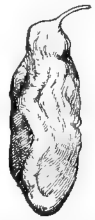
FIG. 1798.—Polypus Removed from the Left External Auditory Canal of a Woman Aged Thirty-six Years. The slender peduncle was attached to the upper and posterior part of the vault of the tympanum. (Actual size.)

DIAGNOSIS.—Our first duty in making a diagnosis is to determine what structures of the tympanum and parts adjacent are involved, and to what extent such involvement has taken place. In order that this may be done properly, it is necessary in every case, at the very beginning, thoroughly to cleanse the walls of the auditory canal and the drum membrane of any secretion or débris which may be present. This once done, we have a clear field for inspection and can arrive at an exact knowledge of the structures under examination. The technique for such cleansing will be dealt with in full when the treatment is spoken of.

The various appearances which the drum membrane presents in this disease are so numerous that it is an impossibility to give an accurate description of them all in detail. Certain types, however, occur more frequently than others, and it is of these that we shall speak more particularly.

Among the commonest perforations are those which occupy the posterior inferior quadrant of the drum membrane. They have rather sharply defined edges, and as a rule the remainder of the membrane is unaffected. The discharge is scanty, and for periods of varying length it may cease altogether. This type of chronic purulent inflammation of the middle ear is seen more frequently in children than in adults, and is usually associated with a poor state of health or with some diathesis.

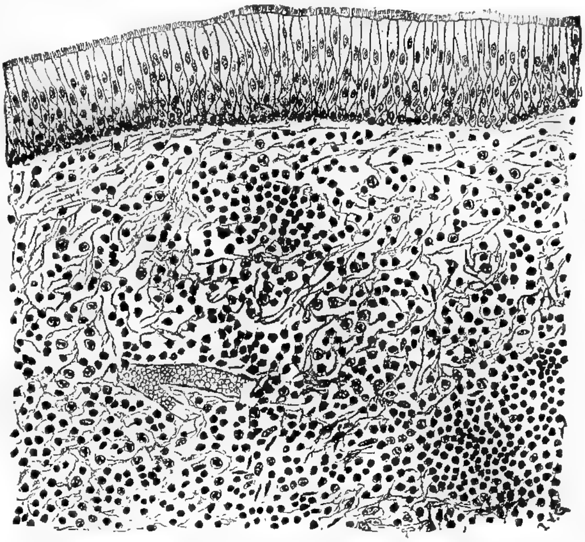
FIG. 1769. Cross Section of a Mucous Polypus, Covered with Ciliated Cylindrical Epithelium. (From a drawing by Dr. Ira Van Gieson.)

In another group of cases we find a perforation in Shrapnell's membrane, about on a level with, or slightly higher than, the articulation of the malleus with the incus. This opening is usually somewhat irregular in shape, and in not a few instances granulation tissue may be seen protruding through it. Such granulation tissue is usually covered with a grayish secretion, which, upon removal, gives forth a decidedly unpleasant odor. Upon passing a fine probe through the opening, we shall almost always encounter diseased bone, existing in an upward and posterior direction.

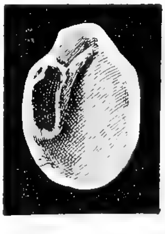
FIG. 1770.—Perforation in the Posterior Half of the Drum Membrane.

In a third group of cases the perforation is of rather large dimensions, involving the greater part of the posterior half of the membrana tympani, and its edges look somewhat jagged and irregular, owing to the existence of bands of adhesions which stretch from the free border of the opening to the adjacent wall of the tympanum. In this group of cases we find either a thin serous discharge present, or, as in the majority of cases, we find an abundance of granulation tissue, with a discharge of a purulent character. If a probe is passed directly upward, or upward and backward, through the perforation, it will, in nearly every instance, encounter exposed and roughened bone within the tympanum.

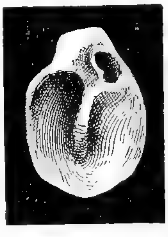
FIG. 1771.—Perforation through Shrapnell's Membrane.

In a fourth group of cases the

membrana tympani will be found to be destroyed throughout from one-half to two thirds of its entire area. The opening, in such cases, usually extends as high as the short process of the malleus above and as low as within a few lines of the inferior portion of the tympanic ring below; it also extends laterally almost to the circumference of the ring, thus showing prominently a goodly portion of the handle of the malleus, almost directly in the centre of the opening. In many of these cases the opening is filled in with exuberant granulation tissue, springing from the inner wall of the tympanum. There may be only a single mass of this tissue or it may be present in two or more distinct masses; and when this occurs, we find one overhanging the other.

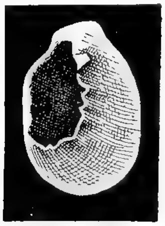

FIG. 1772. — Large Perforation with Irregular Edges, Occupying the Greater Part of the Posterior Half of the Membrane.

In the fifth group we find destruction of the entire membrane, except that portion known as the membrana flaccida, or Shrapnell's membrane. At the margin of this opening we usually find a thick reddish membrane, which extends over the entire background and which is covered with secretion. At first sight this looks like a mass of flattened granulation tissue. In reality it is the thickened mucous membrane covering the inner tympanic wall.

In the sixth group we find complete absence of the drum membrane, except a portion of Shrapnell's membrane, which has been left by the disease, and which through thickening and distortion has entirely lost its natural appearance. The handle of the hammer has been completely destroyed, and if anything is left of the ossicular chain, it is hidden from view behind the thickened Shrapnell's membrane. It is only by using the probe that we are able to ascertain whether these little bones are present or not. In a case of this description we may find that the background—the inner wall of the tympanum—consists either of bone divested of its natural covering, or of thickened mucous membrane. In both of these conditions the amount of secretion present may be very slight. In other cases, however, and especially in those in which proper cleansing measures have not been carried out, there may be a considerable accumulation of a foul-smelling secretion.

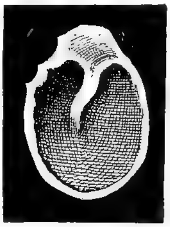

FIG. 1773.—Destruction of Nearly the Entire Drum Membrane; the manubrium mallei remaining in situ and the inner wall of the tympanum being exposed to view.

Finally, in a seventh group of cases, we find, though only in exceptional instances, a white cyst-like body occupying the region of the posterior superior quadrant of the membrana tympani. In some cases the surface of the cyst is dry, but if it has opened spontaneously, or if a puncture has been made in it, a small amount of a purulent secretion, or a thin serous discharge, will be seen escaping from the small opening. The presence of such a condition is due, no doubt, to the fact that prolonged pressure exerted from within upon the drum membrane at this point causes a loss, to a certain extent, of the inherent elasticity of the drum tissue (atrophy of the substantia propria), and later a gradual stretching and giving way of this structure takes place, so that a cul-de-sac or pouch is formed which becomes filled with the retained secretions. During the past year the writer has had occasion to observe one of these cysts in private practice. In size it was as large as a small pea, occupied the middle portion of the posterior half of the membrane, was white and glistening, showed no evidence of any discharge, and was not associated with pain or discomfort. When it was opened, it gave escape to a light-colored serum, which seemed to be contained between the outer and inner layers of the drum membrane, for close inspection failed to establish any posterior opening leading to the tympanic cavity.

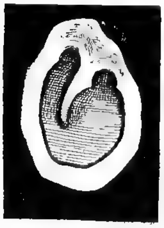

FIG. 1774.—Complete Destruction of the Drum Membrane, except Shrapnell's membrane, with preservation of the entire malleus.

Special Methods of Exploring the Middle Ear in Cases of Chronic Purulent Inflammation.—It is always a very important point, in these cases of chronic purulent otitis, to discover the exact location from which the discharge emanates, as quite frequently we see an area of exposed bone, or a granulating surface covered with secretion or with pus, and are misled into believing that at this point we have found the source of the trouble, whereas in reality we have only exposed to view some subordinate area of inflammatory action—as, for example, a swollen and granulating mucous membrane covering the inner wall of the tympanum, the inflamed condition of which is actually due to the fact that irritating pus from a distant point, situated at a higher level, constantly flows over its surface. In order to make sure of our diagnosis, we should bring to our aid, in the examination, the use of the silver probe, the tip of which should be bent in accordance with the anatomical relations of the particular part which is to be explored. By carefully palpating the various regions of the tympanum, we shall often be able to demonstrate the existence, in some part of the attic, of a sinus, or of a polypoid growth, or of an area of diseased bone. In all cases we should make a most careful inspection of the entire surface of what remains of the membrana tympani, not forgetting the margins at their insertions into the tympanic ring.

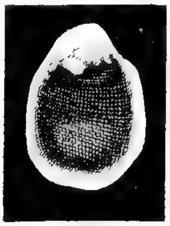

FIG. 1775. — Complete Destruction of the Drum Membrane Proper, Including the Manubrium Mallei.

The method of examining for dead bone in the attic recommended by Dench ("Diseases of the Ear," p. 397) has been found very efficient by the writer in a large number of cases. It is as follows: Wind a small piece of cotton around the point of a delicate probe, bend the latter to the proper angle, and insinuate it gently into the various portions of the tympanum, particularly above the margin of the superior portion of the tympanic ring. In this way, when dead bone is encountered, the cotton at the tip of the probe will often catch upon the roughened bone surface, thus transmitting the sensation to the fingers; or upon its withdrawal we shall find fibres of the cotton which have been pulled upon and drawn from the main mass attached to the end of the probe. Other authorities prefer to use the probe without any such wrapping of cotton. In not a few instances a mass of firm granulation tissue, springing up from the tympanic cavity, has been mistaken, under mere ocular examination, for a bulging drum membrane; but in such doubtful cases the use of the probe will at once render any such error impossible.

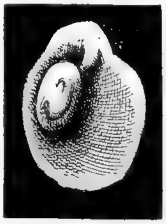

FIG. 1776.—White Cyst-like Mass Protruding from the Posterior Superior Quadrant. (Author's case.)

In cases in which there has been a purulent condition of long standing, followed afterward by a cessation of the secretion and by a partial regeneration of the drum membrane, the perforation may be so small that we cannot locate it upon simple inspection or by passing the end of the probe over the surface of the membrane. Under these circumstances we have at our command two simple and fairly accurate methods of finding out if a solution of continuity exists. In the first, we ask the patient to perform inflation for himself by the Valsalva method, and then we watch what takes place in the drum membrane during this act of inflation. In a certain percentage of these cases we shall be able to note the facts that a slight motion takes place at a particular point, and that immediately afterward there is produced a hissing or squeaking noise due to the passage of the air through a minute perforation. In the second method the inflation is made by means of the Eustachian catheter, and the operator connects his own ear with that of the patient by means of the soft-rubber diagnostic tube. In this manner the hissing or squeaking noise mentioned above will be heard more distinctly than when the other plan is adopted. There are a few other conditions in which it is possible to arrive at a fairly accurate diagnosis. Such are, for example, the following:

When a discharge is finding its way through the membrana flaccida, or Shrapnell's membrane, we may count, with considerable certainty, on finding caries of that portion of the malleus which lies above the tympanic ring, within the vault. If a mass of granulation tissue hangs over the superior portion of the drum membrane, and especially over the membrana flaccida, then we may feel confident that the principal area of disease is located in the vault, that it has been of long standing, and that in all probability both the malleus and the incus are involved. A mass of granulations springing from the region of the superior posterior quadrant would indicate, more particularly, a diseased condition of that part of the tympanum which corresponds to the aditus leading to the mastoid antrum. Furthermore, in all of these cases much can be determined from the character and extent of the discharge; for when the discharge is slight, the area of bone destruction is of a correspondingly small extent. On the other hand, if the existing discharge is profuse, and if it possesses a pronounced odor, then we usually find a much larger area of bone involved. In a very large number of the cases suffering from this disease and accompanied by a discharge, even though scanty, we are enabled by inspection to locate readily the opening in the drum membrane; for when the patient performs Valsalva's method of inflation, we see bubbles of air escaping with the secretion through the opening, at some particular point in the membrane; or we may see only a drop or two of serum or pus forced through the opening. If the pus is very thick and the opening a small one, the former will be forced against the opening in such a manner as to be seen distinctly; and then, when the pressure from behind ceases, the pus will disappear within the tympanic cavity again. In cases in which we are in doubt as to the existence of a perforation, we may derive aid from the use of the pneumatic speculum, but by far the larger number of diagnoses are made by simple inspection rather than by any other method. When only a fissure-like perforation exists, inflation will show that the edges of such a perforation move toward the person inspecting it, and this condition is often seen during the later stages of convalescence, particularly when the perforation exists in the posterior quadrant. It is only rarely that we meet with cases in which the Eustachian tube will not admit sufficient air to aid us in making a diagnosis. At times, when an opening, though small, exists in a drum membrane the tissues of which are greatly swollen, we see upon inspection, at the point where such an opening exists, a distinct, rhythmical pulsation, synchronous with the heart beats. This is due to the tension of the blood in the small vessels at this point.

When the mucous membrane covering the inner wall of the tympanum is exposed, it may very often be mistaken for a bulging and markedly inflamed drum membrane, although scarcely a vestige of the latter may be present. But if we examine carefully with a probe between the margins of the canal and this reddened surface, it will easily be seen that a solution of continuity exists, for the mucous membrane at this point lies on a much lower plane than that of the canal.

In each and every case, in order to arrive at a correct diagnosis, and thus be able to give an intelligent prognosis, an examination of the hearing function should be made. As a rule, the following conditions, with slight variations, will be found to be present in patients suffering from this disease: The acoumeter of Politzer will not be heard so well as whispered words. Words spoken in an ordinary tone of voice are often not heard so well or so distinctly as those spoken in a forced whisper. In many cases it is found that the upper tone limit is normal, while the lower tone limit is elevated. If the disease has lasted over a long period of time—for several years, for example—the upper tone limit is almost invariably lowered, owing to the involvement of the labyrinth. The majority of cases show an increase in bone conduction. When the fork is placed on the vertex of the skull, the patient nearly always hears it more distinctly in the affected ear, and the difference which is ordinarily observed between the bone conduction and that through the air is usually reversed. No mention will be made here of the various signs of mastoid involvement, as this part of the subject is fully treated in another portion of this work.

PROGNOSIS.—In this disease, more than in almost any other form of aural disease, does the prognosis depend upon the treatment and care of the case, for in a large majority of instances the general tendency is not toward a spontaneous resolution. We can usually sum up the prognosis under the following heads: as to *hearing, as to curing the otorrhœa, and as to life.*

As to Hearing.—We should never (except under certain conditions to be named later) encourage the patient to believe that the hearing will be improved when an arrest of the discharge is effected. In fact, it is well known, clinically, that many of the cases do not hear so well after the existing discharge has ceased as they did before, and to such patients the discovery of this fact always brings marked disappointment. The cause of such a diminution in the hearing power is probably to be found in the increased dryness, or diminished succulence, of the soft tissues, and this is particularly true of those which are in the vicinity of the stapedial foot-plate; for here the drying of the soft tissues and perhaps more or less cicatrization can scarcely fail to influence injuriously the mobility of this plate of bone. For this reason, if for none other, each case should be tested functionally when first seen, and this test should be referred to as a standard during the continuance of the discharge and after it has ceased. When any large area of the membrana tympani is destroyed, and particularly when this area corresponds to the upper and posterior quadrant; and when, furthermore, there is no obstruction in the region of the oval window, and we find upon the use of the probe that the stapes is movable, then we are quite safe in telling the patient that, when the discharge ceases, the hearing will be as good as it is at that time, although but little or no improvement beyond this point can with reason be looked for. On the other hand, if adhesions exist, binding down the stapes, we may, by dividing them, effect a distinct improvement in the function of hearing.

When labyrinthine involvement is shown by the tests to be present, then a guarded prognosis should always be given. It was formerly supposed by many that the amount of local destruction would give us a fairly accurate idea as to the extent of functional impairment, but clinically this has been found not to be true; for there are many cases in which, from a mere physical examination, we should be led to give a very bad prognosis as regards the hearing, and yet, when we compare the results of our functional examination in these cases with the physical conditions observed, we are surprised to find that the hearing power is out of all proportion better than we anticipated.

If, upon simply cleansing the external auditory canal and gently inflating the middle ear, the hearing improves to an appreciable degree, we may safely predict that treatment will restore a useful degree of hearing power to the affected ear. If, however, these simple measures produce no effect upon the deafness, and especially if with it there be associated distressing tinnitus and defective bone conduction, we may confidently assume that the case is one in which no remedial measures of any kind are likely to improve the hearing to any material extent. When a large amount of granulation tissue is present over and around the stapes, its removal almost always is followed by an improvement in the hearing, and this improvement continues undiminished so long as the granulations are not reproduced.

If ankylosis of the stapes has already taken place, there will be marked and incurable impairment of the hearing.

As to the Otorrhœa.—In many cases the discharge seems to cease spontaneously without any treatment whatever; but if we follow the history of these cases we shall find that the disease recurs from time to time, usually from the effects of a cold, thus showing that the pathological condition still exists and needs only such an irritant to become active.

If no carious condition of the bone is present and if free drainage exists, then under proper treatment the discharge will cease in a short time; but when it persists, we are sure to find, upon careful examination, that the bone is diseased in one or more of the regions already mentioned. If the ossicles alone are involved in the process, we can then give a favorable opinion as to the cessation of the discharge under proper treatment (mention of which will be made later). If, however, the deeper structures show involvement, and the history is one of long-continued suppuration, then the discharge will not cease until after a radical operation upon these parts has been performed, and this will be spoken of in full in another part of this work. Where no dead bone exists, we can usually promise immunity from mastoid and other involvement. Before expressing an opinion as to the length of time a discharge will probably last, we should always make sure that we have discovered its source; and if we find that it is seated in the attic, we should give a guarded prognosis—at least so long as the patient declines to submit to a radical operation.

The character of the existing secretion will often enable us to give a fairly trustworthy prognosis. Thus, for example, if it is thick and if the drainage is inadequate, we may say that the case will probably be one of long duration. When a discharge has lasted for a long time, and in spite of frequent aseptic irrigations we continue to get a foul odor, both from the discharge and from the recently cleansed canal, we may be certain, under such circumstances, that we are dealing with a case in which diseased bone is present. Again, when we find a profuse, stringy discharge, draining through a large opening in the drum membrane, we may expect that the disease will pursue an obstinate course, on account of the extent of mucous membrane involved. It is not an uncommon experience, in such cases, to find that there is a certain amount of hypertrophied adenoid tissue in the vault of the pharynx; and the removal of it by operative procedure often exerts a most favorable influence upon the otorrhœa.

As to Life.—If at the time of the examination we find no evidence of any mastoid or intracranial involvement, we can safely say that, under proper care and treatment, no danger to life exists; neither is there immediate danger to life even though a simple uncomplicated mastoiditis exists. But if, on the other hand, we find that some intracranial complication is actually present, the prognosis is certainly grave, though not to such an extent as we were wont to look upon it several years ago before the aurist accomplished such brilliant and successful results in the treatment of intracranial conditions. The subjective noises, which are present in some of these chronic purulent cases, have proved to be so disturbing to the mental condition of certain patients that their lives have been in danger from attempts at self-destruction.

In every case in which intratympanic caries exists, there is always present the danger that at some subsequent time the patient's life may thereby be placed in peril. Such diseased tissue should therefore be removed, and the best time for accomplishing this is shortly after the discovery of the fact that bone caries exists in some part of the middle ear. That this is a wise rule to adopt is shown by the fact that in the past very many people have lost their lives from the sequelæ of chronic purulent otitis media, and in quite a large proportion of these it was not even suspected that a diseased condition of the ear was the real cause of death.

Before taking up the treatment of this disease, we must consider its bearing upon the question of life insurance, for the companies are continually rejecting applicants for insurance because they have formerly suffered from this disease; and yet many of the cases so rejected are not rendered, by the mere fact of their having once had a purulent otitis media, less desirable risks than those who have never suffered from such disease. The important question in every such case is, Did the pathological process really undergo healing? If we find in such an applicant complete closure and cicatrization of a former perforation, then such an applicant should be accepted as a risk. If, however, a perforation still exists, even though perfectly dry and perhaps very small in size, then by no means is the applicant an entirely safe risk.

TREATMENT.—In treating a case of chronic purulent inflammation of the middle ear we should have three objects in view: first, the cure of the otorrhœa; second, the improvement of the hearing; third, the relief of the distressing subjective sounds, if present.

In the treatment of the discharge the first cardinal principle is to secure cleanliness, and this can be accomplished in two ways. In the first place, if the discharge is rather scanty, and if the patient can be seen frequently by the surgeon, it will be an easy task to remove the existing discharge by mopping the parts with sterilized cotton wound on a cotton carrier. After the field has been gone over in this way, it should be thoroughly cleansed with some rather strong non-irritating germicide or disinfectant, and one which the writer has found beneficial is the following:

℞ Acid. boric.......... .... gr. xx.
Sol. hydrarg. bichlor. (1 to 1,000)..... ʒ ij.
Spir. vini rect. .... ad ℥ i.
M.

The parts are to be thoroughly cleansed with this solution, and then any granular surface which may be present is to be touched with a small cotton-tipped probe, dipped in silver nitrate, of a strength ranging from 20 grains to 240 grains to the ounce of distilled water. Such applications will, in a large number of the cases, so stimulate these granulations that we may expect, by using such treatment two or three times a week, to effect a speedy cure.

In the second place, if we are dealing with a case in which the discharge is profuse, then the patient, or whoever is to care for him, must be taught the proper method of syringing the ear, and the treatment must be carried on by irrigation. In adults a hard-rubber ear syringe, provided with a blunt point or nozzle, and holding an ounce of fluid, is usually employed for this purpose. In the case of young children, however, it is desirable that the syringe should be of soft rubber in order that it may not irritate the meatus or the canal. In a general way its shape should be like that shown in the accompanying figure (Fig. 1777).

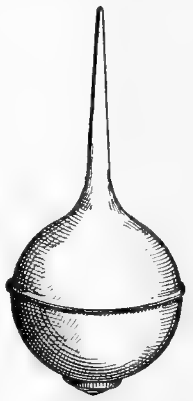

FIG. 1777.—Simple Model of Soft-Rubber Syringe.

A point to be remembered in syringing the ear, and one also to be impressed upon the patient or nurse, is that, in all adult cases, the auricle should be grasped gently between the thumb and fingers of the left hand and drawn upward, backward, and a little outward, thus straightening the meatus and cartilaginous canal and bringing it on a line with the osseous canal. Otherwise, when we use the syringe, we shall be directing the stream of fluid against the side of the canal wall instead of straight into the lumen of the passage. In syringing the ears of a child under three years of age, the auricle should be drawn outward and downward, as this position best aids us to overcome the natural curve of the canal at that age. The frequency of irrigation will depend largely upon the character and quantity of the discharge, and at no time must the latter be allowed to accumulate to any extent in the auditory canal. In an ordinary adult case, the ear should be cleansed every three or four hours at first, and then, as the discharge begins to lessen, the frequency of irrigation may be diminished to three times a day, or once or twice a day, and later even to every second or third day. In a child it will be necessary to irrigate more frequently on account of the smallness of the canal and the tendency of the walls at the orifice to lie in contact, thus preventing the escape of the secretion. In these cases we should irrigate as frequently as every two hours until we notice a gradual lessening of the discharge; and, from this time onward, the frequency may be reduced to every three, four, or six hours, according to the quantity of the discharge that presents itself each day. It is always well to bear in mind that an ear should be irrigated only frequently enough to keep the discharge from accumulating in the canal, inasmuch as too frequent irrigation serves to soften, make flabby, and lessen the integrity of the parts, thus prolonging the disease. Only a small amount of force should be used in irrigating an ear, whether the case be that of a child or that of an adult, and we should never use a cold solution, but one tepid, or slightly warmer, depending upon the amount of comfort given to the patient. The quantity to be used at each irrigation varies anywhere from a quarter of a pint to a pint. Rarely is it necessary at one sitting to use more than the maximum quantity given above.

If irrigation produces, as it sometimes does, disagreeable symptoms, as pain, vertigo, or nausea, and these persist, then, no matter how profuse the existing discharge, we must cease the irrigation and remove the discharge by frequent mopping and cleansing with cotton. In all cases, after irrigation, it is desirable to dry the deeper parts as well as the meatus with cotton.

The various solutions that have been used for syringing the ear are legion, but only those will be mentioned which the writer has found of value from a clinical standpoint.

A solution of bichloride of mercury in boiled water, of a strength ranging from 1 to 5,000 to 1 to 2,000, is the solution most used, and the one from which we obtain the best results at the present time.

A solution of value, and one largely used to-day by the general practitioner, is that of boric acid of the strength of twenty grains to an ounce of boiled water. As a cleansing solution it answers the purpose very well, but, if considered from a disinfecting or germicidal standpoint, it leaves much to be desired.

A solution of carbolic acid in sterilized water, of the strength of one or two per cent., was formerly used, but in recent times it has been practically abandoned. In recent cases, a weak solution of formalin, 1 to 500, is often of service, owing to its active germicidal properties, but even in this strength it has to be frequently discontinued, owing to its irritating qualities. If it be thought advisable to continue its use, a much weaker solution must be employed.

A solution of potassium permanganate, of the strength of half a drachm of the liq. potass. permanganat. in from four to six ounces of sterilized water, is often used to abate the discharge on account of its strong disinfecting properties. It possesses the further advantage that it acts as an excellent deodorizer when we have a foul-smelling discharge to treat.

When a certain amount of exfoliated epithelium is found in the discharge, accompanied by a roughened condition of the canal walls and a roughened and excoriated condition of the meatus, we have found of the utmost value a solution containing from one to two drachms of an eight-per-cent. alcoholic solution of salicylic acid and four ounces of sterilized water; the acid here seeming to exert a marked healing effect on the excoriated tissue.

For simple cleansing purposes, a tepid solution of plain sterilized water will be all that is needed.

In a few of the cases that come under the aural surgeon's observation, the so-called irrigation treatment seems to increase rather than diminish the amount of the discharge. When this occurs, the patient, or whoever is caring for the case, must systematically use the dry treatment spoken of above, in order to obtain the beneficial results desired.

In order to save the patient's clothing while using the irrigation method, we should always have him hold, beneath the ear, a kidney-shaped hard-rubber or agateware basin into which the water coming from the canal may escape. These are easily obtained and are furnished for sale in all sizes.

As soon as the discharge begins to lessen perceptibly, the congestion and swelling gradually subside, and the structures slowly regain their normal appearance.

In all cases, before we undertake the local treatment of the ear, we should make a thorough investigation of the upper respiratory tract, and when we find that these structures are involved in a catarrhal process, we should, while giving the ear proper attention, direct our treatment to the cure of these pathological conditions; for, if they be neglected, we shall doubtless observe that exacerbations of the ear disease—although the latter may be benefited for a time by the measures which we have adopted—occur from time to time, owing to the influence exerted by the pathological conditions in the nose and naso-pharynx. We should search especially for any lymphoid hypertrophies, and if found they should be promptly removed. If we discover any other obstructive condition, which interferes with a normal naso-pharyngeal function, this also should be removed.

When the drum membrane has to a large extent been destroyed, and we find the inner tympanic wall exposed and presenting a mucous surface that is swollen, congested, and covered with mucus, or even if it is only slightly moist, then we must stimulate this surface by applying to it some suitable remedial solution. That which gives the best results is one of silver nitrate. At first a weak solution should be employed, one of ten grains to the ounce of distilled water, and then afterward, according to the indications, the strength may be gradually increased to as much as 240 grains to the ounce, or even to 360 grains to the ounce, when a rapid effect is desired. A point of value in applying the silver solution may be mentioned here, and that is, care should be taken not to touch other parts of the tympanum or any portion of the skin lining the canal. The application should be restricted to the particular area that we wish to stimulate, and this can be accomplished easily by exercising a little care in preparing the cotton-tipped probe. It should not be large or bulky, but quite small, and only the tip should be dipped into the solution; all the excess of fluid should be pressed out from the small mop before we introduce it into the canal, as otherwise there is a strong probability that some of it will come in contact with normal tissues, and thus cause excessive irritation. Other solutions which may be used with beneficial results are varying strengths of the zinc and copper salts; of the latter, a two-per-cent. solution is the one most frequently used.

As the discharge becomes less abundant and the patient is seen less frequently, a solution to be used at home should be prescribed—as, for example, one like the following:

℞ Boric acid .... gr. xx.
Bichlor. of mercury solution (1 to 1,000) ʒ ij.
Absolute alcohol..... enough to make ℥ i.
M.

Five or ten drops of this solution—to be placed in the ear twice a day at first, then later once a day, and finally, as the need for stimulation diminishes, only every second day—will be found to act admirably, not only as a stimulant, on account of its alcoholic properties, but also as an antiseptic, on account of the boric acid and the bichloride solution which the mixture contains.

There are two effective methods of bringing such a solution into contact with the diseased mucous membrane. Either a dropper can be used, or the requisite number of drops can be placed in a small spoon and then poured—after first warming the fluid, if this be thought best—into the auditory canal; in each instance the head being held well over toward the opposide side. If any residue remains after one or two minutes, it can be removed by turning the head in an opposite direction, thus allowing the liquid to escape.

When the discharge is markedly persistent and the applications mentioned above fail to bring about a satisfactory result, the writer has found of benefit the so-called Powell's method of treatment, which consists of the application, to the diseased surface, of a solution of pure carbolic acid (ninety-five per cent.). This is allowed to run into the canal, the head being held well over toward the opposite side, until the auditory canal is nearly filled. It is retained in this position for from thirty to sixty seconds, and then the canal is quickly syringed with a solution of absolute alcohol. In this way the alcohol counteracts any escharotic action which the carbolic acid would exert upon the normal tissues, and yet at the same time the diseased parts are stimulated and thoroughly cleansed. By this form of treatment excellent results are obtained in many cases that would not yield to the ordinary methods in vogue.

The question will naturally be asked as to how great is the amount of pain involved in this procedure. It is very slight, for the carbolic acid exerts an anæsthetic effect superficially; and then, upon the quick application of the alcohol afterward, the patient simply complains of the ordinary stinging sensation which is usually experienced, in a mild degree, upon the application of this liquid.

In all cases under treatment we should, after thoroughly cleansing the canal and before applying the remedy, direct the patient to perform inflation by the Valsalva method, so as to drive out from the middle ear any retained secretion that may be present. Should he be unable to do this, then gentle inflation by means of the catheter should be practised, and the secretion thus displaced should be removed before our final application is made to the surface to be stimulated.

The practice of instilling oil of any kind into the auditory canal should not be countenanced, as it affords a medium which is favorable for the development of vegetable fungi of various kinds; and when once these conditions are established in the canal they prove exceedingly irritating and difficult to get rid of. As to the use of hydrogen peroxide in the auditory canal of a patient suffering from chronic purulent otitis, there is a wide diversity of opinion. Some authorities report most brilliant results from its use, both by syringing the canal freely with it and also by simply instilling it into the canal. They claim that, when so used, it cleans out the small cavities by displacing retained secretions, which otherwise would not appear without the use of this agent. I believe, however, that we have other means at our command that will do the work quite as well, without exposing the patient to the risk of our displacing and driving backward into the mastoid antrum, through the aditus, this retained secretion, and thus exciting an inflammation of this cavity by the infection contained in the secretion so displaced. It must be admitted that such secretion, when it is displaced, can travel this path quite as easily as any other, and the writer has seen several cases of purulent otitis in which, under the employment of hydrogen peroxide, a distinct mastoiditis developed; in fact, in four of them the mastoid had to be opened. In all of these cases there had been no sign of mastoid involvement until after the peroxide was employed, and in a general way the ear affection had been progressing favorably up to the time mentioned;—therefore, from observation and personal experience, I am opposed to the use of this remedy in this form of ear disease.

Under no circumstances or conditions should we in this disease, either early or late, put a large quantity of powder in the canal and allow it to remain, for it becomes moistened and later forms a crust, thus favoring what we wish to avoid, namely, a damming backward of the secretion. Furthermore, the practice of supplying a patient with a quantity of powder to use by himself cannot be too strongly condemned, for in many instances he will cause the secretion to be driven backward,—a result which is brought about by the formation, at the point of perforation, of such a crust as has just been mentioned, and which subjects the patient to the danger of mastoid and other intracranial involvement.

After the discharge has been reduced to a minimum amount, so that it only moistens the parts, then we can use with much advantage some of the many antiseptic and astringent powders, by insufflating a small quantity over the moistened area. The powders more commonly used under such circumstances are: boric acid, aristol, acetanilide, nosophen, zinc oxide, iodol, and alum. Iodoform was formerly used extensively, but owing to its disagreeable odor it has been largely discontinued. This drug is certainly very unpleasant for both the patient and the surgeon, on account of its peculiar odor, and, besides, it often gives rise to a most distressing dermatitis. Dermatol has also been used, but it possesses no particular curative effects. In many cases in which the discharge is intractable and comes from the attic region, the use of the intratympanic syringe is of the greatest value, as by its use we can introduce solutions of various strengths, upward and backward, beyond the point of vision. The writer has used a small glass instrument of various sizes, with short or long tip and broad end, fitted closely with a rubber cap similar to that of the pipette. These little glass pipettes are made in almost any size, and the tip can be made at any angle one wishes. They are easily handled, neat, clean, and inexpensive, and contain, for use in treatment, all the way from one to twenty drops of the remedial fluid, which is usually a solution of silver nitrate.

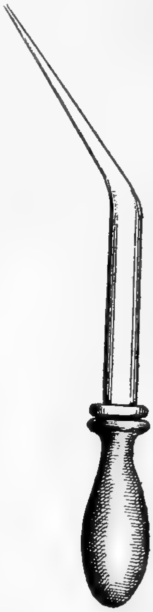

FIG. 1778.—Glass Pipette. Model used by author.

In cases in which we find a large amount of granulation tissue present, we proceed to destroy this after first cleansing the canal and the area to be destroyed. If the granulations are only moderately large, we can easily destroy them by means of chemical agents. The two agents of this character most used are silver nitrate and chromic acid. The surface to be cauterized is first dried, and then upon a metal probe a bead of either of the above agents is fused and applied carefully to the granulating area. Care should be taken not to smear these agents over adjacent parts, and all excess or residue should be mopped up with a cotton pledget. The actual cautery has been recommended as admirable for the destruction of these granulations, but its use here is altogether too difficult of application; and besides, we have other means at hand, equally as good, and much easier to use.

After cleansing the area to be cauterized, we should apply to the granulating surface about to be destroyed a solution of cocaine hydrochlorate of a strength of from five to ten per cent. This application can be made by soaking a small pledget of cotton in the cocaine and carrying it with the forceps directly against the surface we wish to anæsthetize, or we can apply it by means of a cotton-tipped probe, which we are to hold against the surface for a moment or two until the anæsthetic effect has been produced. If this preliminary step is taken in these cases, the patient will experience little or no pain during the destruction of this exuberant tissue; and this in itself is a factor to be taken into consideration, for no one likes to suffer pain when it can be so easily avoided. When the granulations are larger and polypoid in character, then their removal is best effected by means of the wire snare. The loop of the wire is passed over the growth and carried backward and inward to its point of attachment, and then the growth is cut off by the successive turning or screwing of the thumb-piece of the snare, thus tightening at each turn the loop of wire surrounding the growth.

As a more rapid means of removing these growths a sharp curette is preferred by some operators. This instrument can be passed quickly into the canal, at the side of or beneath the growth, and carried backward to its point of attachment, which is usually a rather firm peduncle. When this point is reached, the curette is raised and manipulated so as partially to twist the stalk around the shank of the instrument, care being taken that the sharp curve of the instrument shall rest upon the superior or upper surface of the peduncle. The curette is then pressed inward against the surface from which the growth springs, the peduncle is severed close to its attachment, and the growth is removed at the same time that the instrument is withdrawn. Cocaine should always be used previous to the removal of such growths, in order to relieve the patient of as much pain as possible. As an adjunct of great value in the removal of these growths, we may mention the local use of a solution of suprarenal capsule. The following is the formula used by the writer:

℞	Adrenals (Armour desic.)	ʒ i.
	Boric acid	gr. xvi.
	Cinnamon water	ʒ iv.
	Camphor water (hot)	℥ i.

Distilled water (hot)—enough to make a two-ounce mixure.
M. Macerate for four hours and filter.

The use of this solution, which should be applied particularly to the base of the growth, renders it easy to remove quite large polypi; and furthermore, what would otherwise be a bloody operation is converted, by the aid of this fluid, into one that is practically bloodless. The solution should remain in contact with the tissue to be removed for at least five or ten minutes prior to the operation. The after-treatment is also greatly facilitated by the use of the remedy, for by its aid we can cauterize the base left after the removal of the growth without continually going over the surface for several minutes with cotton pledgets trying to stanch the oozing of blood before we apply our cauterizing agent. Formerly, when the removal of a polypus had to be done without the aid of the suprarenal extract, it was very frequently found necessary to carry out the cauterization of the base at a second sitting on account of the free hemorrhage existing.

For the first twenty-four hours after the removal of such a growth, it is well to pack the canal loosely with a strip of plain sterilized gauze. This acts in a twofold manner. First, its prevents any marked secondary hemorrhage taking place, as sometimes occurs after the use of the suprarenal extract; and, secondly, it acts as a protection; but it should always be removed on the following day. If the patient is not to be seen for a few days, then under no condition should the canal be packed; but if much discharge is present, the patient should be directed to use the irrigation method for a few days until the discharge diminishes sufficiently, or until the patient again comes under the observation of the surgeon for further treatment. In all cases in which exuberant granulations or polypi have been removed from the auditory canal and middle ear, the subsequent treatment is to be carried out on exactly the same lines as those already stated, *i.e.*, the parts are to be kept sterile and clean, they are to be stimulated from time to time as may be needed, and later, when the discharge diminishes, the drops referred to in a previous paragraph are to be used twice a day.

If, after an ear has been treated in this way for a period of ten days or two weeks, the discharge is still present, and there is a marked tendency to a re-formation of the granulation tissue, then it may be said with a degree of certainty that we have to deal with dead bone situated farther back, and no time should be lost in its removal. The technique of this procedure will be found in the article on *Mastoid Operations*, in a later volume.

Aspergillus is quite frequently found just within the meatus, on the canal wall, on the remains of the drum membrane, or on the exposed internal tympanic wall, in cases in which the ear has previously been the seat of a purulent inflammation. Its presence may mislead us into thinking that the ear has begun to discharge again. This new discharge is caused by the presence of this fungus at one or more of the points just mentioned. It develops slowly in the beginning when it lodges upon the surface, owing to a lack of moisture, but later, when even a slight amount of moisture comes in contact with it, the growth is a rapid one, and the discharge given out from it is often offensive and accumulates around the meatus. The treatment required is simply to cleanse the parts by the ordinary method, and then to scrub the surface all over with a cotton-tipped probe dipped in the alcoholic solution previously mentioned. Afterward it is well to insufflate just enough finely powdered acetanilid or boric acid to cover the surface from which the fungus grows. A few treatments like this will suffice to clear up the condition as well as to relieve any excoriations at the meatus which may have been caused by the discharge.

In all cases of purulent disease of the middle ear, in which, upon examination, we find the drainage insufficient, we should lose no time in enlarging the opening through which the discharge is passing; and oftentimes it is desirable, instead of enlarging the old perforation, to make a free incision through the drum membrane at some other point, to facilitate more rapid drainage. This is particularly imperative when the discharge emanates from the lining membrane of the middle ear, and we find it being inadequately drained. It is in these cases that the subsequent use of the middle-ear syringe is of the utmost value, as after a thorough cleansing of the tympanic cavity we can introduce the stimulating or astringent solutions, and a sufficient quantity should be used each time to fill completely the tympanic cavity. The fluid will oftentimes pass into and down through the Eustachian tube, but this will do no harm, provided the solutions used are not too strong, and rarely should we use for the first time in this manner a solution of silver that is stronger than one per cent. If the case is one of a persistent character, this intratympanic syringing should be practised each day until the discharge is perceptibly lessened; then every second day; and later less frequently—for example, twice a week.

When a small amount of discharge continues despite all treatment, and the parts upon inspection look indolent, the method suggested and practised by Blake—viz., that of fitting a small sterilized piece of very thin paper over the existing opening—will oftentimes heal these perforations. It is not improbable that this effect is produced by the mechanical irritation set up by the contact of the disc with the indolent surface of the membrane. In applying these paper discs, after they are approximated closely to the drum membrane, they should be gently pressed around their edges so as to compel the paper to adhere firmly. After the disc has been satisfactorily applied, a small amount of powdered acetanilide or boric acid is to be dusted over its surface. Such a dressing will remain in place for from two to eight days, and when the parts are again inspected, we shall find that the disc, though still adherent to the drum membrane, has gradually worked its way toward the edge of the membrane, exposing a part or the whole of the perforation, while little or no moisture is present. A second disc, sterilized in the same manner, should now be placed over the opening, leaving the primary one undisturbed, and partially overlapping it. Usually two or three such applications serve, in a large proportion of the cases, completely to stop the discharge and close the opening. The protection given by the disc no doubt hastens the favorable changes which take place in the pathological mucous membrane of the middle ear.

To improve the hearing, after we have cured the discharge, is the next step in the treatment of this disease. When a large part of the tympanic membrane has been destroyed and the ossicles are bound down by adhesions, we usually find that the hearing is markedly diminished. However, by dividing the existing adhesions—a procedure which can be quite easily carried out after the discharge has ceased—we often succeed in effecting a decided improvement in the hearing. On the other hand, some of the cases thus operated upon show no improvement. Nevertheless, as those whose hearing is improved by the operation constitute a majority, we should not fail to give this part of the treatment a fair trial. Personally, I have seen only two cases out of a total of twenty-four that did not improve under this procedure.

It is usual, in an ordinary case, in which the greater part of the tympanic membrane remains, for the hearing to improve slightly when the discharge ceases, and under these circumstances we may use, as an aid to restoring the function of hearing, the ordinary method of inflation and vaporization of the middle ear, as it prevents the excessive formation of adhesions, and tends, furthermore, when these adhesions have already taken place, to stretch them, as well as to stretch and make more pliable that portion of the drum membrane which is still intact. This method of treatment should, if possible, be carried out three times a week at first, and as improvement begins to take place, the frequency should be diminished, according to the indications present in each case. In many of these cases, during convalescence, and after the discharge has ceased, complaint will be made of a most distressing tinnitus, one which does not yield even though the frequent inflations spoken of have been practised. In these cases the internal administration of small and gradually increasing doses of the potassium iodide will be followed by a marked relief in a large number of instances. At the beginning the dose should be five grains three times a day, but afterward it should gradually be increased until the desired relief is secured. Usually, when the patient has taken about ten grains three times a day for several days, this symptom will gradually diminish, and, in a fair number of cases, will disappear altogether. This effect, no doubt, is due to the stimulating properties of the remedy, which causes an absorption of a small amount of exudate or recently formed deposit within the middle ear.

If any decided labyrinthine involvement is already present, then, of course, the severing of the adhesions mentioned above is contraindicated, for the operation is not likely to be followed by any improvement.

Excision of the ossicles, and operative procedures for the relief of intratympanic caries will receive full consideration in another article of this series.

In all cases that come under our observation for treatment, we should never lose sight of the fact that we are practitioners of medicine first, and specialists second; and all cases, in which the indications demand it, should have general building-up and tonic treatment in order that the local condition may improve the more rapidly, as it must when the patients receive a surplus of nutrition through the medium of the general system. There are many chronic cases which, if they had been subjected to the building-up process when they were first attacked by the local disease, would never have reached the chronic stage at which they afterward presented themselves for treatment. *James F. McKernon.*

EAR DISEASES: FOREIGN BODIES IN THE EXTERNAL AUDITORY CANAL AND MIDDLE EAR.—

I. AUDITORY CANAL—Although the position of the ear is not such as to favor the entrance of foreign bodies into the external auditory canal, it not unfrequently happens that they find lodgment there. Children are much given to thrusting into their ears such bodies as glass beads, pebbles, coffee grains, and the like; adults "lose" plugs of cotton in their ears or break off in the canal part of a match or toothpick with which they have been scratching an itching meatus or endeavoring to remove cerumen; while insects occasionally enter the ear by accident, and sometimes by design, being attracted, perhaps, by the odor of an offensive discharge. Flies, attracted in this way, now and then deposit their eggs in the ear; and, unless the discharge be sufficiently profuse to wash them out, they quickly develop into maggots, which soon make their presence known by the great irritation they create. Foreign substances are sometimes put into the ear with criminal intent; but, popular belief to the contrary, the auditory canal furnishes a most indifferent avenue for the introduction of poisons into the system, since its dermal lining does not permit of their ready absorption.

The presence of a foreign body in the ear does not necessarily give rise to serious consequences. If the substance introduced possess irritant or caustic properties, inflammation will quickly supervene, the drumhead may be destroyed, and not only the integrity of the hearing, but life itself, may be jeopardized. And, also, when living insects invade the ear, they usually cause—especially when their wings or claws come in contact with the tympanic membrane—great suffering, and, perhaps, severe inflammation of the membrane and the cutaneous lining of the meatus. But, on the other hand, such innocuous bodies as beads, cherry stones, coffee beans, etc., unless they be tightly wedged in the canal, or be so placed as to press rudely upon the drumhead, may scarcely make their presence felt, or induce even a transient earache.

The prevalent belief is that the entrance of a foreign body into the auditory canal is a serious accident, and that, however harmless in itself the foreign substance may be, dire consequences will ensue unless it be quickly gotten out. As a rule, it is doubtless judicious to remove without unnecessary delay any body which has found its way into the external ear, because its presence *may* excite inflammation, or, as sometimes happens, troublesome reflex irritation,* and because, moreover, we shall scarcely be able, without doing so, to allay the alarm of the patient or the anxiety of his friends. But, on the other hand, as in most instances no immediate ill consequences need be apprehended, we should not be too eager to undertake this oftentimes delicate operation, imperfectly equipped, perhaps, for its performance, and under conditions which render doubtful its successful completion; for, if the operation fail of its purpose, the injury resulting from the repeated efforts to extract the foreign body will probably leave the auditory canal inflamed and swollen, and the ear in much worse condition than before. Indeed, the difficult cases which the specialist has to deal with are almost always those in which, through previous unskilful manipulation, the delicate walls of the meatus have been lacerated and bruised, and the foreign body tightly impacted in the bottom of the canal.

Before attempting to remove a foreign body from the ear the operator, by careful inspection, should first assure himself that one is present. This it is not always possible to do without the aid of an ear mirror and speculum. If these are not at command, and there be doubt as to the presence of a foreign body (for it is to be borne in mind that patients frequently imagine that something has entered the ear when such is not the case), it is permissible to attempt to solve the doubt by the use of warm water and the syringe; but, under such circumstances, to grope blindly in the ear, with any sort of instrument, is a practice fraught with great danger and utterly unjustifiable. It may be well to mention that the glistening surface of the tympanic membrane is sometimes mistaken for a foreign body by those unaccustomed to examining the ear; and, as such a mistake is apt to lead to serious consequences, the possibility of it should be borne in mind in order that it may be avoided.

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* Among the reflex phenomena which have been observed in consequence of the irritation produced by the presence of a foreign body in the ear may be mentioned, cough, vomiting, excessive salivary secretion, hemicrania, facial paralysis, and epileptic convulsions (Poulet). The writer also has reported a case (Trans. Am. Otological Society, vol. v., p. 508) in which inability to swallow food was caused by the presence of a plug of cerumen in the ear.

Treatment.—The question of how to deal with a foreign body lodged in the ear depends upon a variety of circumstances: In the first place, upon the nature of the intruding body, whether it be an animate or an inanimate object; and if the latter, whether it be an irritant or an innocuous substance, and what its shape and size. In the second place, upon the manner of its lodgment, whether it be tightly wedged or lying loose in the canal, and whether resting near its orifice or beyond its constricted middle third, in the neighborhood of the tympanic membrane. In the third place, upon the skill and experience of the operator; for what would be a judicious and safe method of procedure for one accustomed to operating upon the ear, might be an extremely unwise and hazardous one for a tyro in this department of surgery to undertake. Generally speaking, it may be said that unless the foreign body be near the external orifice of the ear, and be of such shape that it may be readily grasped by suitable forceps, in the absence of special skill upon the part of the operator, the syringe is the safest and best instrument with which to undertake its removal. In most cases this plan will prove successful, and, when it does not, at least no harm will have been done by the attempt. If it cannot be removed in this way, resort must be had to the forceps, or to the blunt hook devised for this purpose. Neither of these instruments, however, can be used with safety, or to good purpose, unless the meatus be illuminated, so that the foreign body may be kept in view and every movement of the instrument watched. If the intruding body be lying near the external orifice of the canal, it is possible to obtain a satisfactory illumination by turning the ear toward a window or a bright artificial light; but, if it be lodged near its inner extremity, a concave ear mirror attached to a head band, by means of which either diffuse sunlight or artificial light may be concentrated and reflected into the ear, and in most instances an aural speculum, must be employed. Unless, however, the operator be used to this method of examining the ear, he will find that he cannot accomplish much in this way; and, under such circumstances, supposing that the syringe has been tried without avail, he will serve his own interest and his patient's welfare, if without more ado he refer the case (if it be in his power to do so) to some one having more skill in this particular direction than himself; for farther instrumental effort upon his part is little likely to be successful, and may result in serious damage to the ear.

In skilful hands a traction hook, such as is represented in the woodcut, is the most generally useful instrument for the removal of foreign bodies from the ear.* It is especially useful when the foreign body is spheroidal in shape, or is so large as to be wedged tightly in the canal. Under such circumstances forceps are worse than useless; for it is almost impossible to open them wide enough to grasp the foreign body, and each unsuccessful attempt to catch hold of it tends to force it more deeply into the meatus. With the hook, however, which can be gently insinuated between the foreign body and the walls of the canal, and, when it has been gotten beyond it, can be turned so as to catch the body, and, upon its withdrawal, either roll or drag it toward the external orifice of the meatus, any body which has found its way into the ear may be extracted—unless, indeed, it has become greatly enlarged (as sometimes happens from the imbibition of moisture), or the calibre of the canal has been considerably lessened by inflammatory swelling. When such an instrument is not at command, a silver probe suitably bent near its extremity may be used in its stead; or an excellent substitute for it may be fashioned out of an English steel hairpin, by separating the prongs until they form with each other an obtuse or right angle, as may be preferred, bending one into a loop for a handle, and, after filing the extremity of the other prong somewhat flat, bending it over very close to the end and serrating its under surface with a file or knife, that it may more readily catch hold of the foreign body. With such a contrivance the writer has extracted many foreign bodies from the ear. Indeed, it has become quite a favorite instrument with him, and several of these improvised hooks, their extremities differently shaped, form a useful part of his armamentarium. The wire loop of an aural snare, which may be passed around the foreign body, is recommended especially for the extraction of spherical bodies which fill the lumen of the canal, and, it would seem, should answer an excellent purpose. In the case of peas or beans or other softish bodies a sharp hook, which may be made to penetrate and in this way to catch hold of them, is useful. If the body be so impacted that it cannot be drawn out in this way, it may be cut in pieces with the hook or with a narrow-bladed knife and removed piecemeal with the angular forceps or syringe.

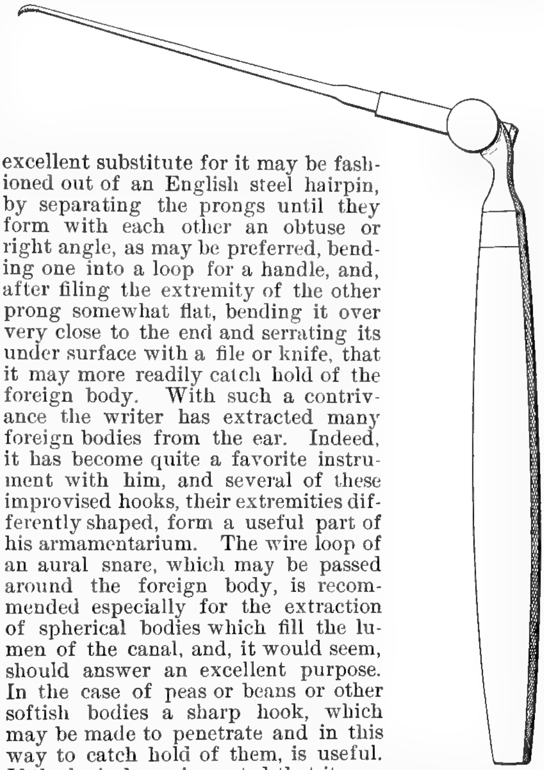

Fig. 1779.—Traction Hook for Removing Foreign Bodies from the External Auditory Canal. (From author's drawing.)

When a corrosive substance finds its way into the ear, it should be syringed out as quickly as possible with tepid water, without loss of time in searching for something which may neutralize it chemically. If such an agent be at hand—as for instance a weak acid, such as vinegar, in the case of an alkaline caustic, or carbonate of soda or potassa, if the corrosive substance be acid, it should be added to the water with which the ear is syringed.

When animate objects invade the ear they usually cause much suffering. Insects, by the rapid movements of their wings and feet, not only excite severe pain, but create an uproar which renders nearly frantic the unfortunate individual into whose ear they have penetrated. Their movements may be arrested, and their lives put an end to, by pouring into the meatus any bland oil, such as olive or almond oil, or melted lard when these are not obtainable. Their bodies may then be removed by means of the syringe or forceps. The writer met with a case some years since in which a physician, possessed of some originality, succeeded in arresting very promptly the distressing movements of a small insect which had entered the ear, by pouring into the meatus a quantity of melted cerate. Unfortunately, however, upon parting with its heat the cerate became hard, and moulded itself firmly in the canal. The remedy, as may be imagined, was worse than the disease, for the discomfort it caused was almost as great, and the difficulty of getting rid of it ten times greater.

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* The writer employs a hook, the shank of which is 6.5 cm. in length and forms an angle of about 100° with the handle. The hook at the extremity of the shank, as represented in the cut, is bent over not too abruptly, and is serrated upon its under surface. In his opinion the angular form is preferable to the straight traction hook which some aurists employ, as with it the operator's hands are less likely to interfere with the illumination of the meatus.

Maggots are not only difficult to remove from the ear, but cause very great suffering, because, as Blake has pointed out, they attach themselves, by an apparatus provided for the purpose, to the walls of the meatus, and feed upon the inflamed integument. It is frequently necessary to seize and extract them with forceps, as the syringe will not always bring them out.[*] They survive for some time in oil, live only five or ten minutes in alcohol, and are killed instantaneously by chloroform (Burnett). Alcohol, however, is not a desirable thing to pour into an inflamed and excoriated meatus, and to use chloroform in this way is, of course, out of the question. Dr. Roosa recommends chloroform vapor and also Labarraque's solution of chlorinated soda to destroy them with, when it becomes necessary to do this before removing them from the ear.

In the removal of foreign bodies from the ear, especially if the walls of the meatus have been lacerated or there is a probability that the tympanic membrane has been injured, antiseptic precautions should be employed. Sterile water should be used in syringing the ear; all the instruments used should be sterilized, preferably by boiling, and the hands of the operator should be surgically clean. After the intruding substance has been removed, it will be well to syringe the ear gently with a sterile, saturated solution of boric acid, and, as a further precaution, to close the orifice of the meatus, but not too tightly, with a plug of sterile cotton.

To relieve the pain and inflammation caused by a foreign body in the ear, or by the efforts to remove it, the writer has found useful the French anodyne oil, known as *oleum compositum* or *baume tranquille*,[†] of which eight or ten drops may be warmed and dropped into the ear three or four times a day. Perhaps, a still more efficacious remedy is the solution of atropine and cocaine (atropia alk., gr. i.; cocaine alk., gr. ij.; ol. amyg. dulc., ʒ ij.) which the writer has recommended in the treatment of otitis media, and of which six or eight drops may be poured into the ear as often as may be thought desirable.

To facilitate the removal of foreign bodies from the ear the anæsthetic action of cocaine (ten-per-cent. solution) or holocaine (two-per-cent. solution) may be availed of; but, as might be anticipated, the effect obtained is not very satisfactory. With nervous children, it is necessary, in many cases, to administer a general anæsthetic, not so much to lessen the pain of the operation (which in uncomplicated cases should not be considerable), but to overcome the fear and quiet the resistance of the patient.

II. Tympanum.—Foreign bodies occasionally find lodgment in the tympanic cavity. They commonly enter through the external auditory canal, but exceptionally reach the cavity by way of the Eustachian tube. When the tympanic membrane has been destroyed by pre-existent disease, a foreign body which has entered the auditory meatus may easily find its way into the tympanum. Usually, this happens, however, in consequence of awkward efforts to extract it. When the ear previous to the entrance of the foreign body is in normal condition, rupture of the drumhead must, of course, take place before it can pass into the cavity beyond. This, again, happens commonly through persistent and unskilful attempts to remove the body from its original point of lodgment. It may occur also when the foreign body has entered the ear with such force as to drive it at once through the membrane, as, for example, might happen with small shot fired from a gun. Again, the destruction of the membrane and the passage of the body beyond it may be due to the caustic action of the latter, or to its being so lodged as to cause continuous pressure upon the membrane, leading in time to ulceration.

As might be supposed, by the other route of entrance—the Eustachian tube—substances other than fluids very rarely find their way into the tympanum. Still, instances of this character have occurred. Urbantschitsch has reported a case in which a fragment of an oat stalk entered the tympanm in this way, and another case is on record in which a broken bit of a hard-rubber syringe passed from the nose into the drum cavity by way of the Eustachian tube. Ascarides have also been known to enter the tympanum in this manner. (Cf. also p. 591.)

The passage of irritant fluids from the nasal cavity into the middle ear is a misadventure of comparatively frequent occurrence, and often gives rise to unfortunate results. It usually happens as a consequence of employing a nasal douche, and formerly, when this practice was more in vogue than it is at present, severe cases of otitis media brought about in this way were constantly coming into the hands of the aural surgeon.

The consequences likely to ensue from the presence of a foreign body in the tympanum are, as might be supposed, usually more grave than when a similar body is lodged in the external auditory canal. If it has entered by way of the Eustachian tube the irritation provoked by it will almost certainly lead to suppurative inflammation of the middle ear with perforation of the membrane. This, indeed, is nature's method of ridding itself of the offending body, and in most instances it is likely to succeed, the foreign body escaping, with the discharge, through the external ear. If the foreign substance has been forced through the drumhead from the external canal, or has passed into the tympanum through a previously existing perforation, inflammation, attended by severe pain and probably by symptoms of cerebral irritation, is likely to supervene quickly, and still more serious consequences may ensue, unless, by surgical interference, relief is obtained.

It should be stated, however, that some ears are very tolerant of the presence of a foreign body even in the tympanic cavity, and that such serious consequences as have just been described do not invariably follow. "As illustrative of the slight degree of disturbance which may be set up by the presence of a foreign body in the drum cavity," to quote from Dr. Huntington Richards' excellent article upon this subject in the first edition of the Reference Handbook (p. 359), "reference may be made to certain cases related by Voltolini (*Monatsschrift für Ohrenheilkunde*, 1876, No. 5) where a Politzer's eyelet, a small, smooth body made from hard rubber, lay within the drum cavity without exciting inflammation, and to a case reported by Bartscher and quoted by Gruber, where for nine months a corset ring lay impacted in the tympanum of a child previously affected with chronic otitis media purulenta, without giving rise to serious trouble."

Since nearly all that has been said in regard to dealing with foreign bodies lodged in the external ear applies to similar bodies in the tympanum, there remains but little to add as to the *treatment* of this class of cases. When the drumhead is intact it is difficult, and may be quite impossible, to assure one's self of the presence of a foreign body in the cavity beyond. The inflammation which is almost sure to supervene would of itself probably call for the making of a free incision in the membrane; so that, under such circumstances, one need not hesitate to resort to this measure to facilitate the escape of the body, because of uncertainty as to its presence. On the other hand, if symptoms of inflammation have not manifested themselves, such a step would hardly be warranted, though there might be no room for doubt as to the presence of the foreign substance. When the body has entered through a perforation in the tympanic membrane, or has been forced through the membrane, it will sometimes be necessary to enlarge the opening to facilitate its removal, whether this be attempted with the syringe, with slender forceps, with some form of traction instrument, or with a polypus snare, as von Troeltsch has recommended. The possibility of driving the foreign body from the tympanum by forcing air or a non-irritating, sterile liquid—such as normal salt solution—through the

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[*] The writer once removed from the ear of a woman a live tick, which had been there for about a fortnight. It was firmly attached to the wall of the meatus, and when it was seized with forceps considerable traction was required to break its hold. A black granular material (its excrement) had been coming from the ear for some days, at times a sound "like broiling" had been heard in it, and pain was beginning to be experienced.

[†] For formula see French Codex, and National Dispensatory, 5th edition, 1894, p. 854.

Eustachian tube, by means of the air bag and catheter, should not be lost sight of. Finally, it may be added that if the operation of displacement of the auricle and cartilaginous meatus is ever indicated for the removal of a foreign body from the ear, it is in cases in which such body is impacted in the tympanic cavity. Among others who, under such circumstances, have resorted to this procedure with success may be mentioned Israel, Moldenhaur, Bezold, Huber, Politzer, Buck, Roosa, and Bishop.

Samuel Theobald.

EAR DISEASES: GENERAL THERAPEUTICS.—In writing upon general aural therapeutics a practical division of the subject has seemed to me one of the great difficulties. That previous writers have experienced the same difficulty seems shown by the fact that scarcely two of them have written along parallel lines. Almost every one has divided this chapter in a different manner from all the others. At first it seemed to me as if the rational plan would be to take general symptomatology as a basis; the objection to this, however, is the fact that each symptom is, or may be, produced by many of the individual diseases, and that general therapy along this line would resolve itself more or less into a consideration of what could be done for these individual diseases, which seems without the scope of such a chapter as this one.

Considerable deliberation on the subject has resulted in the determination to pursue the following line of thought:

First. To consider briefly some prophylactic measures whereby those having sound ears may avoid and overcome conditions which are prone to originate ear diseases, and whereby those already the subject of such conditions, or already having some ear trouble, may take such precautions as will tend to prevent those conditions from growing worse.

Second. To take up the subject of local remedies, under which heading will be considered those procedures in more or less frequent use, such as blood-letting, heat, cold, inflation by the various methods, massage, electricity, etc., and to assign to them in a general way their various values and uses; and finally,

Third. To consider very briefly general remedies—*i.e.*, the treatment of the ear by means of constitutional measures.

I. Prophylaxis.—"To prevent disease is better than to cure disease" has become a trite saying, and to-day, more than ever before, do we very properly follow out the principles of prophylaxis, both in general medicine and in our own limited specialty of otology. Much can be accomplished in many cases by the carrying out of simple, yet important, hygienic measures, in other cases through a practical and timely resort to medication or to operative procedures.

In order to a wise prevention a moment's consideration must be given to the manner in which the ear becomes involved as a result of general or local disease elsewhere. We know that under normal conditions, and in perfect health, we carry about in our mouths a large number of pathogenic germs, whose possibilities for harm are beyond question. We remain in health so long as the normal protective factors retain their functional activity; but when they suffer injury, then these pathogenic factors become capable of harm to the health. One of the most important factors in protection—a factor which varies in efficiency according to the locality—is the unbroken continuity of the epithelial layer; another is the fact that some germs and their products are antagonistic to others.

Inflammatory processes in the ear may develop from within and also from without. By far the most frequent point of origin is the naso-pharynx. Given a "cold" or a surface chill, a congestion of the naso-pharyngeal mucous membrane is sure to develop, and soon thereafter there will be a decrease or cessation of the ciliary activity of the tubal epithelium; and with this will be associated an interference with the normal ventilation of the tympanic cavity, which is thereby rendered much more accessible to pathogenic germs.

From without arise injuries and inflammatory processes of the auricle and external canal which may extend from there to the parotid region, the side of the neck, or the mastoid process, or which may set up some general disease, *e.g.*, erysipelas, or may reach the tympanic cavity. These paths, or methods, of infection point the way for prophylaxis, or for treatment in the early stages.

Preventive measures should begin then with the naso-pharynx, and first of all may be mentioned some of the simple means that should be employed when a condition of health exists. An important matter is the hygiene of the mouth and naso-pharynx, where may at any time be found a list of germs that is already astoundingly large, but is still growing. The care of the teeth, even among those who give them care, is, as a rule, insufficient; they should at least be thoroughly cleansed on retiring and on rising; I believe, too, with Dio Lewis, in the proper use of the toothpick after each meal, and, if this is supplemented by a mouthful of water forced rapidly to and fro between the teeth to as far as possible wash out any remaining fragments of food, certainly the condition of most mouths would be much improved. Gargling may also, in my judgment, be made a more valuable cleansing means than is ordinarily the case. The noisy process with which we are most familiar accomplishes but little, the fluid employed not reaching as a rule beyond the anterior pillars.

The following procedure, described by Haug, is, I believe, much better: "Take a medium-sized mouthful of some good antiseptic mouth wash, throw the head partially, not too far, backward, allow the fluid to run by gravity slowly and quietly downward until the reflex irritation causes a contraction of the muscles of deglutition, when the head is thrown slightly forward, and the contents expelled through the mouth." By this means certainly the tonsils and much of the pharynx, possibly also some of the naso-pharynx, are influenced by the cleansing process.

In acute catarrhal inflammation of the naso-pharynx and nose, whether in the form of a simple angina or as a symptom of measles, scarlatina, etc., the middle ear is threatened; and here we may properly say a word or two in relation to the various procedures which may compress the air in the naso-pharynx, and as to which prophylaxis requires a warning. First of all, as regards blowing the nose—a homely subject, but one of decided importance. So far as is possible this should be avoided during the first few days of such an acute coryza, and, when it must be done, let it be done with both nostrils open, and as gently as is possible; for, as a matter of fact, it accomplishes but little good, whereas the tendency is distinctly toward an increase of the congestion, which in turn increases the desire to again blow the nose. Again, snuffs which cause sneezing are, as a rule, irritating, and sneezing itself, especially if it be a person's habit more or less to suppress it, may forcibly open the Eustachian tubes with bad results. Adopting the same line of reasoning we should say a word against the use—certainly the general and indiscriminate use, without previous cleansing of the nose and naso-pharynx—of the various therapeutic measures (Valsalva, Politzer bag, and Eustachian catheter) which cause compression of the air in the naso-pharynx and tympanic cavity. This precaution is advisable, not only so long as the acute naso-pharyngeal irritation remains, but also during the continuance of pain and deafness in the ear, with exudate in the tympanic cavity. The danger to be feared is that fluid, and with it the agents of infection, may be forced back into the mastoid antrum and cells.

During many of the acute illnesses of infants and children, or even of adults, especially if attended by symptoms not easily accounted for,—*e.g.*, coma, gastro-intestinal disturbances, etc.,—a daily inspection of the tympanic membranes may wisely be made, so that, if occasion arises, prompt incision may be made, and thereby certain dangers and unnecessary destruction of tissues be avoided.

In the case of people, whether children or adults, who are the subjects of frequently recurring or chronic colds or catarrhs, the hearing is at all times more or less threatened. The cause of such catarrhal manifestations needs to be carefully looked for and removed, and consists usually in some form of nasal obstruction or intranasal pressure. Under this general designation comes adenoid hypertrophy, by far the most important single item to be mentioned under the heading of "prophylaxis of ear diseases." The presence of these glandular masses must be looked upon as a distinct threat to the hearing not only of children, but—and upon this point I wish to lay special emphasis—of adults as well, even those who may not necessarily in childhood have had the ear symptoms attributable to adenoids. I say this because I am thoroughly convinced of the need, from the aurist's standpoint, for removal of adenoids when present in any considerable amount, even though the ear symptoms at the time be slight or nil. The faucial tonsils, while not exerting by any means the same harmful influence upon the ears as does the enlarged third tonsil, may still, when much enlarged, and especially if the seat of frequently recurring acute inflammatory attacks, do considerable harm. They should therefore be removed, both in the interest of the ears and in that of the general health.

The nasal douche, when considered from the viewpoint of the ear, must, on the whole, receive our condemnation, since occasionally, even when used with much care, it is the source of violent middle-ear and mastoid inflammations.

Inflammations of the auricle, external canal, and middle ear, arising from external causes, are many of them capable of easy prevention. Eczema, erysipelas, tumors, inoculation tuberculosis, and abscesses of the lobule, are all of them conditions which may, and do, arise from piercing the lobe of the ear for the wearing of earrings, and may all of them, therefore, be prevented if people can be reasoned, or shamed, out of that form of vanity which is especially an inheritance from our heathen ancestry.

Improper methods of cleansing the external canal are accountable for many ear troubles, *e.g.*, for simple impaction of cerumen, for localized and diffuse inflammations of the canal walls, and even for serious middle-ear troubles, all of which are largely or entirely preventable. I refer to the various ear spoons of wood, hard rubber, ivory, or metal, ear sponges, penholders, toothpicks, matches, hairpins, the twisting of the corner of a towel into shape for use as a boring machine, etc. I would include here also the frequent syringing of healthy ears, and the senseless use of oily and other drops, such, *e.g.*, as are applied to the ear for the relief of earache. All the evils attending these various manipulations may be avoided if we, the members of the medical profession, will instruct our patients that wax is a normal secretion, that an all-wise Providence has provided natural methods for its removal, and that, finally, ears in health can be cleansed, and *should* be cleansed, by means of a moist cloth stretched over the end of the index finger.

Injury to the ear as a result of foreign bodies is so slight, and that due to unwise and unskilful efforts to remove them is so great and so easily preventable, that I cannot avoid the mention of the one means—a suitable syringe and warm water—whereby a very large proportion of them can be harmlessly removed, and relentlessly to condemn the almost universal early resort to forceps and such injury-working measures.

The principles underlying prophylaxis impel me also to say a word relative to another condition, often simple in itself, viz., traumatic perforation of the tympanic membrane. A majority of such cases, if left alone,—the canal being gently wiped out with cotton moistened with some antiseptic, and then plugged with a little sterile cotton,—recover without serious results; while, on the other hand, they may be seriously complicated by even such seemingly harmless measures as syringing, etc.

The general question of sea-bathing seems of sufficient importance to warrant us in devoting a few lines to its consideration. For this purpose it is necessary to divide people into two large classes—those who have, and those who have not, a perforation of the tympanic membrane. In the former class sea-bathing is attended with very considerable danger, because in them the harm arises through the water reaching the middle ear by way of the external auditory canal; for this class the safe course is to avoid bathing of any kind, especially sea-bathing, without taking the utmost precautions against "getting water in the ear." This danger can be warded off to a large extent, although not entirely, by tightly plugging the affected ear with "non-absorbent" cotton. In the second class, injury, when it arises, is due to the water reaching the tympanic cavity through the nose or mouth, the nasopharynx, and the Eustachian tube. The danger to this class is far less than to those with perforated membranes, but that danger exists is shown by the very considerable increase of acute middle-ear affections which is observed during each bathing season. However, the risk is, on the whole, so slight that, offsetting against it the benefit to be gained, we cannot in a general way advise against sea-bathing.

II. Local Remedies.—1. *Blood-letting.*—Local blood-letting is of use almost exclusively in acute inflammatory processes of either the external or the middle ear, and especially in their early stages. Its effect in such cases is, as a general rule, amelioration, in a fair proportion, cessation, of the pain. In the chronic hyperæmias not much effect is to be looked for. The abstraction of blood is usually accomplished by means of either the natural or the artificial leech. The number of the former used varies from about one to three in young children to three to six in adults. When the inflammation is located in the external canal, membrana tympani, or tympanic cavity, the leech should be placed close in front of the tragus. The surface of the mastoid should be selected in case of inflammation within that process. When the application of leeches is left to the patient's own management, it is advisable to mark with ink the exact spots upon which it is desired that they be placed. At the same time provision should be made for rendering the skin of this region, before the leeches are applied, as nearly as possible aseptic. The canal is also to be closed with cotton, and careful directions should be given as to how the after-bleeding may be controlled. For the latter purpose the following measures will be found useful: Apply a pledget of absorbent cotton to the wound, and keep up pressure upon it for several minutes; apply styptic in the place of absorbent cotton; or, finally, make pressure by means of adhesive plaster or by an application of iodoform collodion. Whatever material may have been used, it should not be removed for several hours after the bleeding ceases.

The field of usefulness of the artificial leech is somewhat limited, owing to the frequent tenderness existing at the spot where it would naturally be placed. Its special advantages are, that it can be had and used in localities where the natural leech is not procurable, and that in the shortest possible time a considerable quantity of blood can be removed.

The quantity of blood to be taken will of course depend upon the needs of the case; from 30 to 100 gm. being the usual limits. The time when the blood should be abstracted seems to be of some importance; Schwartze's rule is, to do the operation in the evening and then to insist on absolute rest and quiet the following day. If after a second abstraction of blood relief is not obtained, other measures should be employed. Scarification of the canal walls has been much used, and is recommended as an efficacious means of blood-letting in inflammation of the soft parts of the canal. Of all the forms of artificial leech, Bacon's is perhaps the most practical.

2. *Heat and Cold.*—(*a*) *Heat:* From time immemorial heat in some form or other has been a much-used means of quieting pain in the ear. As a home remedy it has been applied in almost every conceivable way, and to the charge of having used heat in many objectionable forms the medical profession too must plead guilty. Heat has been applied to the ear in the form of a roasted onion, of flaxseed and bread-and-milk poultices, of warm oil, glycerin or vaseline, of warm milk, and even of warm urine,

etc.; and among the objectionable ways of using heat I would include the introduction of hot sweet oil and laudanum, hot almond oil, hot cocaine solutions, etc., which are still extensively recommended by druggists and others. At present we speak of using heat in either the moist or the dry form. As sources of dry heat may be mentioned the hot-water bag, a hot brick, an electric-light bulb, a "Japanese stove," Leiter's coil, etc. Moist heat too may be used in various ways: the hot-water ear bath of von Troeltsch, consisting of the frequent filling of the external canal with hot water from a spoon; the ear douche from a special apparatus or from the fountain syringe, or Fayette's ear douche, by means of which a constant stream of continually renewed water of proper temperature flows through the canal and over the face of the membrana tympani.

It is my belief that most, if not all, of the virtue claimed for the various forms of ear drops in relieving earache is due to the fact that they are put in the ear warm. If this be so, then more virtue can be obtained from hot water, because with it a nearly continuous heat can be secured, with the additional advantage that, when we cease using it, the ear after simple drying is left clean. As between dry and moist heat, it is generally believed that moist heat rather favors suppuration; therefore, if in a given case it is thought that suppuration may still be avoided, the choice should favor dry heat.

(*b*) *Cold:* The use of cold as an antiphlogistic measure in inflammatory ear affections is of much more recent date, and, even before the general prejudice against cold in these conditions has been entirely overcome, already the pendulum of professional opinion is beginning to swing back toward heat as the preferable measure. During recent years, however, cold has been much used, especially for the pain accompanying acute mastoid involvement. It can be conveniently employed by allowing a continuous stream of ice-cold water to flow through a Leiter's coil surrrounding the ear; or by means of the aural ice-bag; or, in accordance with the plan of Winternitz for bringing about a contraction of the carotid artery, by the use, in the antero-lateral region of the neck, of a cold compress or its equivalent, whereby, it is asserted, the temperature in the external auditory canal can be distinctly lowered. To sum up, as to heat and cold: in pain due to inflammations of the external canal and of the tympanic cavity, heat is almost universally approved—in the moist form, when it is desired to favor suppuration, in the dry, in cases in which there is still a chance of avoiding it. When the mastoid process is involved, heat and cold both have their adherents, while some are beginning to oppose both because of the fact that they may obscure a condition already in many cases difficult of recognition. All agree, however, that if either heat or cold is employed in this class of cases, it should not as a rule be used for more than from twenty-four to forty-eight hours.

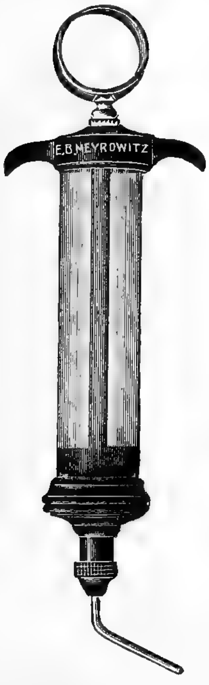

FIG. 1780.—Metal Ear Syringe with Glass Barrel.

3. *Syringing the Ear.*—Under this heading may be considered both syringing of the external auditory canal, and syringing of the tympanic cavity—the latter, either through a tympanic-cavity cannula, or, more rarely, through the Eustachian tube. The immediate purpose of all ear syringing is to remove either foreign bodies or pathological secretions. It may also, however, prove to be directly curative of the pathological processes themselves; *i.e.*, while it removes the foreign bodies or the impacted cerumen, it cures at the same time the associate inflammatory disturbance. Syringing, however, is commonly employed as the first preparatory step in an examination of the ear or in instituting treatment.

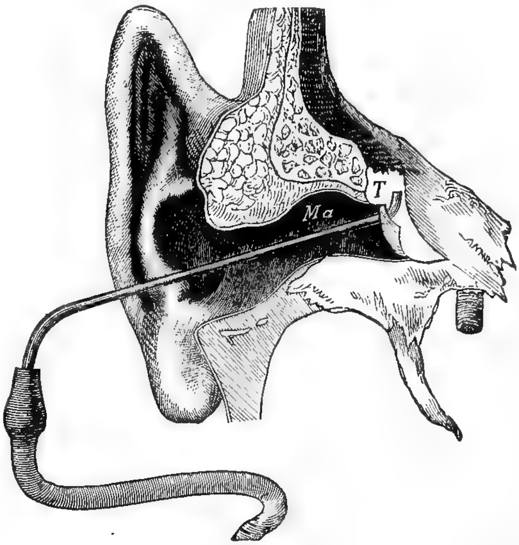

FIG. 1781.—Diagram Showing Hartmann's Cannula in Position.

As to syringes, they may be constructed of hard-rubber, metal, or glass. They should have a capacity of from two to four ounces. The tip may vary according to individual preference; the one shown in the cut has given me better results than any other, though I recognize its possibilities for harm if carelessly used. On the other hand, an olive-shaped tip may be dangerous through its interference with the return flow. For convenience of manipulation there should be attached to the barrel, at the proximal end of the syringe, two rings, and to the plunger, one ring. It is of great importance, from the view-point of cleanliness, to have the syringe fitted with an asbestos plunger, so that the whole thing can be regularly sterilized by boiling. For use by the patient, although as a rule patients use no syringe efficiently, probably the best and safest is either an irrigator or aural douche (fountain syringe), or a hard-rubber syringe of one-ounce capacity; for children perhaps the rubber ball with soft-rubber tip will answer the purpose best.

Water that has been sterilized by boiling, and cooled to a temperature of from 100° to 115° F. (the best general rule is to use it as hot as the patient can comfortably bear it), is the best fluid to use in the syringe or douche. If desired, and especially if the solution is for use in the tympanic cavity, boric acid may be added to the point of saturation, or table salt to the extent of a 0.75-per-cent. solution. The temperature is important, since if the fluid used is too cool, very disagreeable symptoms may result, such as vertigo, nausea, vomiting, syncope, and even prolonged unconsciousness. The same symptoms may develop if too much force is used, the rule being to begin with the least possible force and gradually to increase until the object of the syringing is accomplished, provided threatening symptoms do not sooner develop. At the same time the canal should be straightened with the left hand, and the thumb and index finger should be used as a support for the nozzle end of the syringe, in order that all danger of injuring the canal walls may be avoided.

For washing out the tympanic cavity through a perforation in the drum membrane, specially bent tips attached directly to a small syringe, or to a bulb syringe, or to a simple rubber cap (Fig. 1782), are useful. Of these the best and most generally used is that known as Hartmann's tympanic-cavity cannula (see Fig. 1781).

Syringing of the tympanic cavity through the Eustachian tube is not much resorted to in this country. It presupposes, as a matter of course, a free exit for the liquid used through a perforation in the membrana tympani, and requires a catheter, fitted at one end by the syringe, and fitting at the other end rather snugly into the mouth of the Eustachian tube. It seems to me a rare occasion indeed when all that this method will accomplish cannot be more easily and better done in some other way. This criticism applies with even greater force to the method of Saemann and Gruber, by whom it is recommended that, in some cases of perforation of both membranes, the ear be syringed out by means of Politzer's method of inflation, with the single difference that the air bag, instead of being filled with air, be filled with water of a suitable temperature.

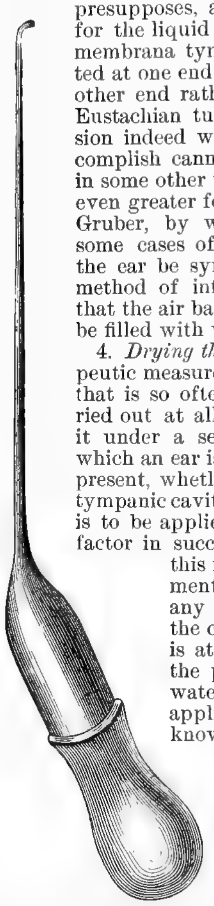

FIG. 1782.—Glass Middle-Ear Pipette.

4. *Drying the Ear.*—This seems to me a therapeutic measure of sufficient importance, and one that is so often wrongly carried out, or not carried out at all, as to warrant us in speaking of it under a separate heading. In all cases in which an ear is syringed, or in which secretion is present, whether in the external canal or in the tympanic cavity, and especially if any medication is to be applied, thorough drying is an essential factor in successful treatment. The reason for this is evident: the amount of medicament that can come into contact with any particular portion of the skin of the canal or mucosa of the tympanum is at best small; if this be diluted at the point of contact by ever so little water or secretion, the strength of our application becomes at once an unknown quantity.

This drying may be best accomplished by means of absorbent cotton and a cotton carrier; the *small* pledgets of cotton being applied under a good illumination of the parts. The pledgets used at the termination of this drying process should be so small as to pass through the perforation of the membrane, and absorb and remove the moisture from within the tympanic cavity. For the same reason I believe that patients should have impressed upon them the importance of drying the ear as a part of the home treatment, and I find that, as a rule, they can be taught to accomplish this with a fair degree of success by means of small pledgets of cotton rolled together between the thumb and finger of one hand to such a consistence as to hold their shape and reach nearly or quite to the bottom of the external auditory canal—beyond this of course a patient cannot safely go. The dry treatment of suppurative conditions, including dry cleansing, will undoubtedly be treated in detail elsewhere.

5. *Compression and Rarefaction of Air.*—(*a*) *Air Compression:* The technique of using compressed air—by Politzer's method, catheterization, etc.—is described elsewhere. To my lot falls a short discussion of its therapeutic use.

The influence of the air douche is first of all mechanical. In the next place, by opening the Eustachian tube it ventilates the tympanic cavity, and makes pressure on its walls, especially on the membrana tympani, pushing it outward, and with it the ossicular chain, thus tending to rectify a position of the membrane which is pathological, and to lessen the fixation of these parts. The same pressure is exerted upon the movable parts of the labyrinth walls—the two fenestræ, thus more or less affecting the intralabyrinthine pressure. As a further effect of the procedure, there may be, and probably is, some slight tendency, on the part of the air current, to catch up small portions of mucus, germs included, and force them from the naso-pharynx and Eustachian tube into the tympanic cavity.

Upon the tympanum the effect is dependent upon the presence or absence of a perforation in the tympanic membrane. If a perforation exists, secretion is pushed through it into the external canal. If there is no perforation, it is still possible that a portion of the secretion, if not too thick and if the head be held in a proper position, may be forced out through the Eustachian tube and thus escape into the naso-pharynx. More usually, however, the air and secretion become mixed up and spread out in a thin layer over much of the surface of the tympanum. The further influence produced by the changes in the air pressure upon the circulation and the lymph stream seems to require a word, since, according to Kessel, the lymph vessels in the tympanic mucosa show round or sac-like enlargements, and stand in open communication with the tympanic cavity. If this be true, then pressure upon the mucous membrane should cause a movement of the contents of the lymph vessels in the natural direction. With the lessening of the pressure the lymph spaces are refilled from the tympanic cavity, and in this way a sort of suction is produced which must effectively aid the absorption of the mechanically broken-up and spread-out secretion. However this may be, experience proves that absorption of secretion can be accomplished by the use of the air douche.

The therapeutic effect to be obtained from Politzer's method of inflation seems much more limited than that from the Eustachian catheter, and to be attended with rather more risk of harm. The former would seem to find its legitimate use especially in cases with perforation of both tympanic membranes, when it is desired to empty the cavities of secretion; and possibly in children with tubal catarrh, as a temporary expedient until the condition is removed by proper attention to the cause. Catheterization, on the other hand, would seem to be the better method when the desire is for the ventilation of one ear only, and in the chronic cases.

(*b*) *Rarefaction of the Air:* This procedure has been used in the external auditory canal to affect the membrana tympani and ossicles, as well as to influence the intralabyrinthine pressure; it has also been much recommended for the removal of secretion from the middle ear. When the membrane is intact it may be used through the Eustachian tube, but in the case of a perforation it should be employed through the external canal. To get the desired effect in the canal the simplest means consists of a piece of rubber tubing armed at one end with a tip which tightly fits the meatus, and at the other with a mouthpiece through which suction is applied. The same principle is involved whether the suction be made by an empty rubber bag, as with Siegle's otoscope, or with the Delstanche *raréfacteur*. A word of caution as to all these methods is necessary, since if rarefaction is too vigorously applied, the result may be a rupture of the vessels with ecchymosis, or even rupture of the membrana tympani itself. The therapeutic effect most frequently obtained is a lessening or cessation, for a longer or shorter time, of tinnitus, a lighter feeling in the ear and head, and less often a gain in hearing.

The most frequent manner of using this principle for the removal of secretion from the tympanic cavity through the Eustachian tube, corresponds in a general way with the process for inflating the ear, with the difference that the air bag, supplying the suction power, is applied to the catheter empty instead of full, the effect being more or less enhanced by placing the head at the same time in such a position as to favor the escape of fluid through the tube. This method of necessity presupposes that the secretion is thin, and in suitable cases the procedure is oftentimes attended by appreciable results.

6. *The Use of the Eustachian Bougie.*—Opinion has varied greatly in regard to the use of the Eustachian bougie. Many have claimed excellent results from its use, while some have put their very positive stamp of

disapproval upon it, as an instrument capable of doing much harm. While it must be admitted that, if carelessly or unskilfully used, serious injury may result, can this not be said with equal truth of all good measures whether medical or surgical? For myself, I am sure that much good can be accomplished with the Eustachian bougie, especially in cases in which tinnitus and deafness are in a measure due to stenosis of the tube. The ordinary celluloid bougie answers well the purpose.

A closely allied therapeutic measure is that which is based upon the use of the metallic (gold) bougie, or electrode. This consists really of the bougie plus electrolysis, and some authorities claim that much more good is to be obtained from this procedure than from the use of the bougie alone, especially in those cases in which the strictures are dense and tight. The use of the bougie for massage of the isthmus tubæ will be spoken of under massage.

7. *Massage.*—The application of massage to the organ of hearing may be accomplished in various ways, and various parts of the ear may be thus treated. In the first place, going from without inward, may be mentioned that form of massage which was first described by Gerst, then elaborated by Zaufal, and finally warmly recommended by Schwartze. In this form the massage is applied *to the region around the auricle*, and is said to have its greatest value in promoting the absorption of secretion from the tympanic cavity in acute middle-ear catarrh. Zaufal's description of the method follows: "The patient sits with bared breast, and head inclined to the opposite side, on a low stool. The masseur stands behind the patient; both hands, well anointed with vaseline, are laid flat, one on the mastoid process, the other on the parotid region, so that the index finger of one presses upon the root of the sterno-mastoid muscle, the other on the anterior edge of the tragus; then rub downward, at first lightly, then with increasing pressure, to the level of the shoulder, so that the pressure of the index fingers is exerted especially in the groove between the ramus of the jaw and the head of the muscle, as well as upon the vessel furrow below." He recommends daily three sittings of three minutes each, or two of five minutes; and that in acute processes it should be deferred until the fever has disappeared.

Secondly, massage of the membrana tympani and ossicles, applied by some one of the various methods, may be used directly or indirectly. In case of its indirect application the cylinder of air in the external auditory canal is used as a medium for alternate rarefaction and compression. "Tragus pressure," as recommended by Hammell, may be mentioned first on account of its great simplicity. By rapid to-and-fro pressure on, and releasing of, the tragus, the air in the canal is thereby alternately compressed and rarefied, thus causing more or less motion of the membrana tympani and ossicles. The procedure is to be carried out by the patient from four to six times daily, each time for a minute or a minute and a half, and at the rate of from one hundred and twenty to one hundred and fifty times per minute. Although this method is frequently recommended by a number of aurists, I cannot say that I have ever seen much benefit from its use.

The same principle, it seems to me, can be much more effectively carried out by means of Siegle's otoscope, Delstanche's *masseur*, or some similar apparatus. In a certain proportion of the cases the tinnitus is certainly somewhat relieved, at least temporarily, and less often the hearing manifests some improvement. In a somewhat similar manner the massaging force has been applied by means of more or less powerful sound vibrations, as produced by the vibrophone, vibrometer, etc. I mention these procedures, however, only to condemn them.

Direct application of massage to the membrane and ossicles may be accomplished by means of the flexible pressure probe of Lucæ, applied to the short process of the malleus, or by the mechanical vibrators of Lester, Freudenthal, and others. My experience with the so-called mechanical massage is, I must confess, limited, but it has been sufficient to force upon me the conclusion that its use is not likely to be very extensive on account of the marked tympanic congestion which results, as well as on account of the pain experienced by the patient.

Intratympanic massage seems to me to be well worthy of mention here. For its accomplishment it is necessary that a more or less rapidly interrupted stream of compressed air, cold, warm, or medicated, should be conducted through the Eustachian catheter and tube against the inner surface of the membrana tympani. Its use is naturally limited to a great extent to the treatment of chronic middle-ear catarrhal conditions.

Finally, *massage of the isthmus tubæ* has been recommended by Urbantschitsch and more or less used by many of us. It is carried out as follows: a probe-pointed bougie (celluloid) is pushed through the Eustachian tube to the isthmus, and then rapidly (from one hundred and fifty to two hundred and fifty times per minute) moved in and out, first in the bony, then in the membranous portion. Begin with a session lasting a half-minute, and gradually increase the length of time of the sitting to three or even five minutes, with short pauses. The special indication for the employment of the method is to be found in the tubal swelling which accompanies chronic middle-ear catarrh, in which cases it should do more good than simple dilatation, the benefit manifesting itself by better hearing and less tinnitus.

8. *Local Medication.*—This may be applied: (1) to the region around the ear; (2) by way of the external auditory canal; (3) by way of the Eustachian tube.

(1) *The application of drugs to the region around the ear* is limited almost entirely to (*a*) sedatives, in the form of salves or liniments, and (*b*) to counter-irritants, mostly applied to the mastoid region. The power of either for good must of necessity be slight, while the use of the latter in certain acute mastoid affections may be positively harmful through the masking of symptoms which at best are not always easy to determine.

(2) *Medication by way of the external auditory canal* is of much value, because a direct therapeutic effect can be obtained upon the disease processes of the canal and membrana tympani, and, if the latter is perforated or a sinus exists, upon the more or less distant parts of the tympanic cavity. Liquids, powders, or solids may be used. Of great importance for the successful employment of this mode of treatment is the previous thorough removal of all secretions, etc., which, by covering the parts, by diluting the medicament, or through chemical combination, may limit the effect of the drug. All fluid applications should be warmed, and should be introduced by means of a pipette or spoon, the head being inclined to the opposite side and the external canal straightened; after which, by appropriate pressure on the tragus, the fluid can be forced further into the canal, into the tympanic cavity, or even all the way through the Eustachian tube into the naso-pharynx. A prolonged effect may be obtained by saturating a pledget of cotton and placing it in contact with the affected part.

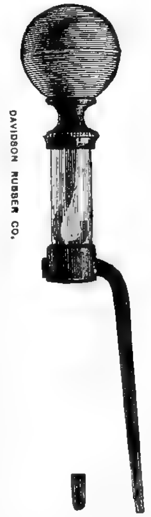

FIG. 1783.—Davidson's "Powder Blower," with End-Pieces of Two Different Sizes.

Medication of the external and middle ears by means of powders has been, and is, a much-abused method. If the material is finely pulverized, or triturated, and used in small quantities, excellent results are often obtained in cases having a fairly large perforation in the tympanic membrane. For the introduction of powders into the ear various powder blowers have been devised, of which the one shown in the cut (Fig. 1783) gives excellent satisfaction. For use by the patient a glass tube, with an attachment of rubber tubing and a mouthpiece, answers a good purpose.

Caustics—such as chromic acid and nitrate of silver (fused on the end of a slender probe)—are applied through the external canal. In using them it is of great importance to the patient's comfort that *only* the desired spot be touched, and that too only after thorough cleansing and drying. Under this heading may be mentioned a special form of local treatment, that of aural suppositories or bougies, of medicated gelatin, as suggested by Gruber; these are introduced into the ear by means of forceps, and then afterward the canal is closed with cotton.

(3) In case of an intact membrana tympani fluids and vapors may be introduced into the tympanic cavity *through the Eustachian tube.* Only small quantities (from eight to ten drops) should be used at a time, and only after being warmed. After the catheter is in position, introduce into it with a syringe or pipette the requisite amount of the fluid to be used, and then with the air bag blow it with some force into the tympanic cavity, always using the diagnostic tube for information as to the successful carrying out of the manœuvre. The entry of the fluid into the tympanum may be facilitated by having the patient swallow at the moment of emptying the air bag, by having the head well inclined toward the side to be medicated, and by using a catheter which enters well into the mouth of the tube. Steam, plain or medicated, formerly much used in the treatment of middle-ear catarrhs, has now largely given place to volatile medicaments (chloroform, chloride of ethyl, menthol, etc.), or to some of the vaporized or nebulized oils containing various substances in solution. By using some one of the well-equipped nebulizing apparatuses the fine vapors can be thrown, warm, into the tympanic cavity through the catheter, with rapid interruptions, so as to obtain a threefold effect, viz., that of the medicated oils, that of the heat, and that of the pneumatic massage acting upon the inner surface of the membrane and the ossicles. While the injection of fluids into the tympanum is certainly less in vogue than formerly, still with caution, especially as to the fluids used, it sometimes accomplishes beneficial results, mostly for tinnitus, when other means fail.

9. *Electricity.*—The general aural therapeutics of electricity furnishes a good illustration of how great an absence of unanimity there may be in the profession relative to a given subject. While as regards the value of electricity in diagnosis and prognosis there seem to be a few who think alike, when it comes to the question of therapeutics there exists the most astonishing divergence of opinion. It is true that there are competent observers who claim good results from the treatment of the ear by galvanism, faradism, static electricity, and cataphoresis. It is also true that equally good observers have utterly failed by the same methods to obtain similar results. In a general way, as the result of a moderate amount of experimenting, I am compelled to cast in my lot with the latter class At the same time the effort to bring order out of what is at present a state of semi-chaos, is a fascinating one. I believe that much good thought and considerable time are being given to the subject, and that the time is not far distant when those who are prosecuting these studies will be able to give to the medical world some greater uniformity of thought in regard to this matter than now exists.

It does seem in some measure settled that there are cases of tinnitus which are benefited, and even cured, by both the constant and the interrupted current. This appears to be especially true of those cases in which a morbid state (either torpidity or hyperæsthesia) of the auditory nerve exists. It is also easy to believe, what seems to be pretty well proven, that electrolysis is useful in the treatment of strictures of the Eustachian tube, as well as in connective-tissue strictures of the external auditory canal. The use of the galvano-cautery in the external and middle ears, although it has been highly recommended, seems to me to present no advantages over other methods, and to be fraught with greater possibilities for harm.

In the present uncertainty as to the value of electricity in aural therapeutics, it seems to me better to refer any one wishing to investigate the subject, to treatises and articles in which the general and special methods of application can be more exhaustively handled than would be possible in the present article.

III. General Remedies.—It is self-evident that general conditions are often of the utmost significance in local disease; that ear diseases may both cause and arise from constitutional disturbances, and that the cure of the former may be greatly hindered unless our therapeutic efforts take into account not only the local disease, but the general bodily health as well. Suppose, for example, a disease of the ear has for its underlying cause tuberculosis, anæmia, disturbances of nutrition, etc.; the best results can be obtained only by using all the therapeutic procedures, medicinal, hygienic, dietetic, etc., which medical science offers for the cure of these conditions. The following should receive careful attention: the climatic conditions; the condition of the dwelling-place; the choice of bedrooms; the proper ventilation of the house; and the suitableness of the clothing. A general tendency to take colds must be combated; the condition of the general circulation is an important factor; outdoor exercise may have to be urged; the school life of children often needs regulation; tobacco and alcohol will need to be limited or stopped; and, finally, the evil effects of late suppers, venereal excesses, masturbation, etc., must all be done away with. Changes of climate from cold to warm, and vice versa, or from the seashore to the mountains, often accomplish, especially among children, what local treatment utterly fails to effect. Patients who show a tendency to frequently recurring stubborn middle-ear catarrhs, as well as those who are subject to the milder transient catarrhal attacks, need a stimulation of the superficial circulation. Such patients may often be benefited by baths, saline, hot and cold, Russian, Turkish, etc.

Treatment of ear diseases by internal medication, formerly almost the exclusive treatment, still has its uses. For example, purgation in acute ear processes, especially in those of full habit, after blood-letting, is of practical use, as it is also in chronic passive hyperæmic conditions of the ear. Pilocarpine, which is so effective in inducing sweating, may also afford material aid to local treatment, in cases of acute and chronic middle-ear catarrh, by favoring the absorption of exudates or as yet unorganized inflammatory products in the internal ear. A kind of specific action has been ascribed to the use of quinine, in the manner recommended by Charcot, in Ménière's group of symptoms. Although in general I do not approve of the use of narcotics, antineuralgics, and antipyretics, in affections of the ear, there are times when it seems necessary to prescribe them.

Suggestion and hypnosis have been recommended for the cure of hysterical deafness, and Urbantschitsch claims to have achieved success with it in the relief of tinnitus as well as deafness. Other writers also have published good results from its use. Nevertheless, great caution must be urged upon those who contemplate dealing with remedies such as these. *J. E. Sheppard.*

EAR DISEASES: INTRACRANIAL COMPLICATIONS OF ACUTE AND CHRONIC INFLAMMATIONS OF THE MIDDLE EAR.—The intracranial complications of suppurative otitis are due to infection of the brain and its membranes by the same microbes which are infecting the ear, the infection reaching the brain either through caries of the bone in direct relation with the brain, through some of the natural passages which lead from the aural cavities to the brain, or through some of the connective-tissue fibrils and minute blood-vessels which pass through the bone. The intracranial disease originates, in most cases, at the point where the infection has penetrated the cranium; consequently, when the extension is through the roof of the tympanum or mastoid it is in the cerebrum, and where the extension is through the medial wall of the mastoid or through the labyrinth it is in the cerebellum. The intracranial infections of otitic origin manifest themselves as pachymeningitis, leptomeningitis, brain abscess, and sinus-phlebitis.

Pachymeningitis is an infective suppuration of the external surface of the dura mater. It may be limited in extent about the spot where the infective material entered the skull, and by adhesion of the dura to the bone the pus may be confined to a small area—the so-called extradural abscess; or it may be diffusely spread out over a large surface of the dura. When the dural inflammation forms about the lateral sinus it is called perisinous pachymeningitis; when over the tympanic roof, epitympanic pachymeningitis. When an extradural abscess has formed, it may be large enough to produce brain pressure; but when the pachymeningitis is diffuse, the pus is usually in such a thin layer that marked brain pressure is wanting.

Pachymeningitis is the most frequent of the intracranial complications. Jansen asserts that it is four times as common as sinus-phlebitis, and twenty times as common as brain abscess. Perisinous pachymeningitis is its most common form. Pachymeningitis is very often associated with one or more of the other intracranial diseases; the most common being phlebitis of the lateral sinus in connection with perisinous abscess.

Symptoms.—In the majority of the cases the development of the disease is insidious, and marked by no symptoms whatever that can be distinguished from those of the ear affection, the pachymeningitis being discovered on removal of the carious inner wall of the mastoid or of the carious tympanic or mastoid roof. In exceptional cases, and particularly in children, there may be in the beginning a chill with fever. Other symptoms, when present, are due to pressure on the brain: headache, general or localized on the affected side; slowed pulse rarely; and somnolence. Fever is the exception rather than the rule, except in the last few hours of life.

Leptomeningitis (an infective suppuration of the arachnoid and pia) is often the closing scene in cases of brain abscess, sinus-phlebitis, and pachymeningitis, but in more than half the cases it exists alone and is due either to a general sepsis or to infection of the arachnoid and pia through the minute blood-vessels. There are two distinct varieties of the disease: the rapid, almost apoplectiform variety, usually fatal in from a few hours to two or three days; and the protracted variety, of from two to three weeks' duration.

Symptoms.—Fever and headache are the two prominent symptoms. In the rapid variety the fever is high (104° to 106° F.), with a very variable curve and continuous; in the protracted variety it is alternately high and normal or subnormal. In both varieties headache is usually present in the earlier stages, in most cases of a very intense character and referred to any part or the whole head. It is, however, often remittent; exceptionally the headache is only slight. As the disease progresses symptoms of irritation of the brain appear: restlessness, excitement, sensitiveness to noises and light, nausea, delirium. From irritation and pressure on the gray substance of the convexity of the cerebrum we may have convulsions of the extremities, with monoplegic or hemiplegic paralyses; from exudation in the fossa Sylvii, occasionally motor aphasia. From involvement of the base of the brain there may be symptoms of irritation and pressure on the cranial nerves of the base, showing themselves, in the ocular muscles, as strabismus and ptosis, or as dilatation or contraction of the pupil without reaction to light; in the facial as facial paralysis; in the vagus as disturbances of respiration. Constipation is almost always present.

Diagnosis is easy in the rapid variety, for the high fever, the excruciating headache, and the brain irritation followed by paralytic symptoms, monoplegic or hemiplegic, —in the extremities when the disease is in the convexity of the cerebrum, or in the cranial nerves (third, fourth, fifth, sixth) when the disease is at the base of the cerebrum, or in the seventh, eighth, and tenth when it is at the base of the cerebellum,—leave no doubt when the disease of the ear and of the bone has been already recognized. In the protracted variety the diagnosis is very difficult in the earlier stages, for the moderate headache and remittent fever are found also with sinus-phlebitis, and, only when the serious disturbances of the sensorium set in, can the diagnosis be absolute.

Lumbar puncture (Quincke) and examination of the cerebro-spinal fluid which is withdrawn are in some cases of undoubted value in proving the diagnosis, but in what proportion of the cases cannot yet be said to be determined. The presence of the pyogenic organisms, the Streptococcus and Diplococcus pneumoniæ, is confirmatory of the existence of leptomeningitis, as is also probably that of the Staphylococcus aureus and albus, but the absence of the organisms cannot be said to exclude the disease. For a detailed description of the method of procedure see Vol. II., p. 248.

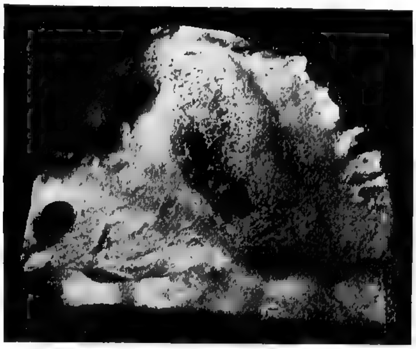

Fig. 1784.—Caries of the Sigmoid Groove. Leptomeningitis of cerebellum.

Treatment.—Ice to the head, best by a Leiter's coil, and leeches behind the ear and to the temporal region, with morphine subcutaneously, often afford a certain measure of relief. By exposure and incision of the brain membranes, in cases in which the disease was circumscribed, Macewen has effected a cure in several instances.

Prognosis.—Only within the last few years has the prognosis of otitic leptomeningitis been considered other than absolutely unfavorable; coma sets in, sometimes with convulsions, and death ensues. The opinion now seems to be gaining ground that patients occasionally recover, although anatomical proof of this is very difficult. The otitic intracranial diseases present usually such a confused mass of symptoms that when a recovery from apparent leptomeningitis takes place one is apt to consider that an error in diagnosis has been made, but I myself—judging from my own clinical experience and from that of others—believe that recovery does sometimes occur. The only anatomical proof I can offer is that of a case of otitic brain disease which presented all of the characteristics of leptomeningitis, and yet recoverey was perfect; but, death having occurred six months later, from another disease, the autopsy showed old adhesions with slight thickenings of the dura, arachnoid, and pia over the convexity of the cerebrum on the side of the ear affection. These were considered by the pathological experts to be the result of leptomeningitis, but, unfortunately, the value of the specimen was not appreciated, and no thorough examination and report of it were made.

Brain Abscess is much more common from chronic than from acute tympanic suppurations, the proportion being variously given at from 83 (Jansen) to 91 (Grunert) per cent. for chronic, against 17 to 9 per cent. for acute. In 92 (Körner) per cent. of the cases the bone is diseased directly on to the dura, and the abscess is usually connected directly with the suppurating ear, either lying directly against the diseased bone, or situated within the brain at a distance of from a quarter to half an inch from the diseased bone, but connected with the latter by a fistulous tract. In 9.5 per cent. of the cases there are multiple abscesses, usually connected by fistulæ. In 6.6 per cent. (Körner) the abscess lies within the brain, and is separated from the bone by normal brain tissue, it being assumed, in these cases, that the infection was communicated by phlebitis of the minute blood-vessels or along the connective tissue accompanying the blood and lymph vessels. The common seats of abscess are, in the cerebrum, the middle and posterior portion of the temporal lobe in the third temporo-sphenoidal convolution; in the cerebellum, the outer portion of the lateral lobe close to the inner wall of the mastoid. Less common seats of abscess are, in the cerebrum, the second or first temporo-sphenoidal convolutions of the temporal lobe, the frontal lobe, and very rarely the occipital lobe; in the cerebellum, in its extreme anterior portion. The path of infection decides this; when the latter travels by direct contiguity through the roof of the tympanum or mastoid the abscess is in the third temporo-sphenoidal convolution; when it extends along the vessels or connective tissue, the abscess may be in the other portions of the cerebrum; when it extends by direct contiguity through the inner wall of the mastoid, the abscess will be in the lateral lobe of the cerebellum; and, finally, when it extends by continuity through the labyrinthine cavities, the collection of pus will be found in the extreme anterior portion of the cerebellum, close to the aqueductus vestibuli or meatus internus.

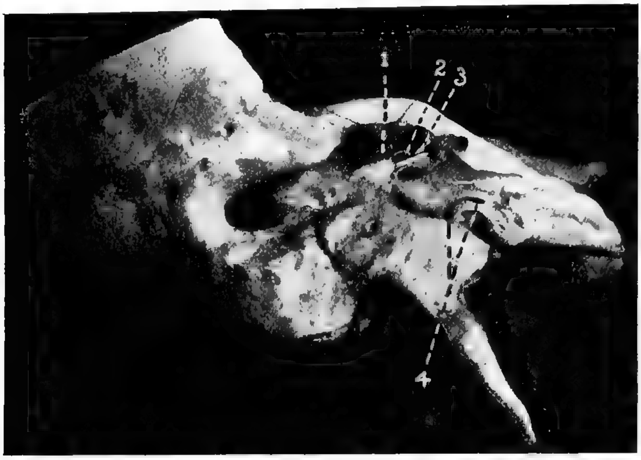

FIG. 1785.—Abscess of Cerebellum from Infection Through the Labyrinth and Meatus Internus. 1, Caries extending into external semicircular canal; 2, caries involving the vestibule; 3, facial nerve exposed by carious destruction of the bone; 4, caries extending into the carotid canal.

Symptoms.—These are divided into four stages: *initial*, marking the beginning of the encephalitis, and often showing a slight inflammatory fever, but this usually so slightly marked that it is referred to the tympanic suppuration; *latent*, sometimes of weeks' or even months' duration, with only occasional slight brain symptoms, slight headache, depression, and perhaps moderate evening temperature; *manifest*, from a few days' to several weeks' duration, when many of the characteristic symptoms of brain abscess to be spoken of show themselves; *terminal*, usually rapidly fatal from increasing brain pressure, brain œdema, or rupture into the ventricles.

The manifest symptoms are well classified by von Bergmann into (1) general, (2) brain and brain pressure, (3) local.

The *general symptoms* are referable to the suppuration alone, but are seldom very pronounced—usually a slight evening rise of temperature and anorexia; chills are rare. Slight intermittent rises of temperature are common, but a steadily rising temperature is against the probability of abscess. In children the fever may be more pronounced.

Brain and brain-pressure symptoms are produced by a diminution of the space within the skull. There is headache, persistent, varying in intensity, but not usually severe. Its location, however, is no indication of the situation of the abscess. Slowing of the pulse is often present, but is not constant, and sometimes disappears, probably from the breaking down of the brain tissue and consequent relief to the pressure. Dizziness, nausea and vomiting, and constipation are common; disturbances of the sensorium in the form of slow cerebration and drowsiness are very common, but delirium is rare. Convulsions of the extremities and of the facial may come from pressure on the temporal lobe of the opposite side; general convulsions are usually due to pressure on the cerebellum. Optic neuritis is often seen, usually of slight degree. All of these symptoms may disappear and then reappear, being most pronounced during the evening fever; and von Bergmann says that if, at this time, the pulse becomes slow and the patient somnolent the suspicion of abscess is increased.

Local brain symptoms are produced by (*a*) direct injury of brain substance, (*b*) by action of the abscess on parts away from the seat of disease, or (*c*) by injury of the cerebral nerves.

(*a*) If the abscess is in the white substance—the common position,—no localizing symptoms are present; such are only to be expected when some centre of the gray matter of the cortex is involved, and it is extremely rare for an abscess actually to destroy the centres in the cortex, and symptoms from these centres are consequently rather due to pressure from a distance than to actual destruction. In very exceptional cases such destruction may occur.

(*b*) Pressure of the abscess on distant parts (Fernwirkung, as the Germans term it) through the intervening tissue is the most common cause of localizing symptoms emanating from the brain and the usual cause of injury of the cerebral nerves. Any such pressure is limited,

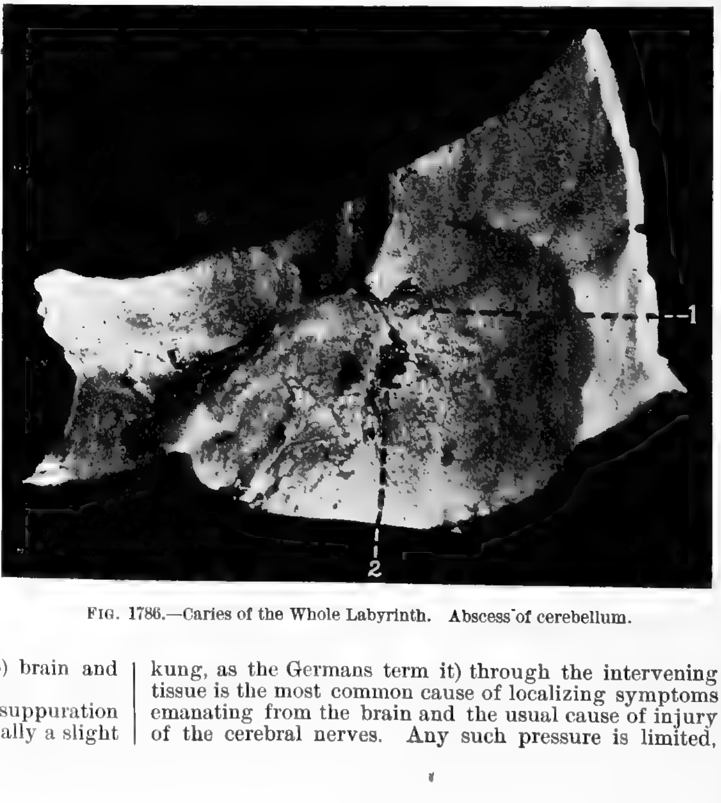

FIG. 1786.—Caries of the Whole Labyrinth. Abscess of cerebellum.

however, absolutely by the tentorium, and consequently cannot extend from the cerebrum to the cerebellum or vice versa. It is not limited toward the internal capsule, the lenticular nucleus, the facial, and the motor and psycho-sensory tracts, and is only partially limited by the pia between the temporal, frontal, and occipital lobes. In the cerebrum the seats of otitic abscess are almost universally in the temporal lobes, lower frontal lobes, and the occipital lobes; rarely if ever in the parietal lobes. The temporal lobes are by far the most common situation. The determined focal centres in these parts are the motor speech centre, in the lower part of the third frontal convolution in the Rolandic cortex; the general auditory area in the superior (first) temporal convolution in the cortex surrounding the temporo-parietal sulcus, where the auditory nerves have their ultimate distribution, probably by complete decussation; the sensory speech centre in the posterior two-thirds of the superior (first) temporal convolution, just in front of the angular gyrus; the visual centre in the posterior portion of the inferior parietal lobe, *i.e.*, the angular gyrus; and the primary visual centre in the occipital lobe (cuneus). The inferior frontal (third), the superior temporal (first), and the inferior parietal gyri represent the confines of the zone of language, the former for kinæsthetic perceptions, the next for auditory perceptions, the last for visual perceptions.* Perversion of function of the zone of language gives aphasia, and, as the most common seat of abscess is in the temporal lobes, aphasia in some of its many forms would be looked for in these cases if any localizing symptoms existed. As a fact this is the case; in 83 abscesses in the left temporal lobe 52 showed disturbances of speech—viz., 7 word-deafness, 11 paraphasia, and 22 amnesic aphasia, which included 14 cases pure, 5 with monophasia, 4 with alexia or agraphia, and 3 with optic aphasia; while in 12 no accurate analysis of the variety of aphasia was made.†

It must be remembered, however, that these determined centres apply to the left cerebrum in right-handed persons, and to the right cerebrum in left-handed persons, although it seems probable that the same centres exist in the opposite hemispheres, but are only partially developed.

In most cases an accurate and careful analysis of the exact form of aphasia is impossible to the surgeon who finds the case urgent. What he wishes to know is whether he is to look for the pus near the Rolandic fissure or in the central or posterior portions of the temporal lobes. Given the aphasia, if he can decide whether it is motor or sensory, he has an answer. Sensory aphasia is a defect in speech due to interference in the reception and interpretation of speech; motor aphasia is a disability in respect to externalization of speech.‡ To put it roughly, it may be said that if speech is not understood we have sensory aphasia, if speech is not possible we have motor aphasia; that, however imperfect the patient's speech may be, if he understands what is said to him, the aphasia is motor; that if he cannot think of the word wanted, although he is able to say it, the aphasia is sensory; but that, if he can think of the word but is unable to say it, the aphasia is motor. Absolute impossibility of speaking must not be looked for, however, in motor aphasia, and Collins adds to the above description of motor aphasia that the patient may be able to articulate one or several words which he uses pertinently or non-pertinently; that the words used are often recurring utterances; that agraphia always exists and is proportionate to the aphasia, showing itself in voluntary writing and in writing from dictation, but not in writing from copy, for in copying he copies print in script, and script in script, thus proving not a mechanical but an intellectual act; finally, that defective internal speech is present.

Sensory aphasia points to the posterior portions of the temporal convolutions, while motor aphasia points to the neighborhood of the Rolandic fissure. From pressure on the motor, facial, and psycho-sensory tracts of the internal capsule may be produced crossed pareses of the extremities, crossed convulsions, and crossed hemianæsthesia and hemiopia.

Abscesses of the cerebellum encounter no distinct brain foci. The function of the cerebellum is still but imperfectly understood. Luciani describes it as an organ giving motor innervation to all the voluntary muscles, but particularly to those of the lower extremities and to the spinal stretchers, and having also a tonic, static, and trophic function. The vermiform process of the cerebellum is considered by Nothnagel and von Bergmann to be concerned in equilibration. From these observations we should expect motor disturbances with convulsive action in the muscles, especially of the lower extremities and back, and disturbances of equilibrium,—symptoms which have been observed but not with sufficient frequency and critical analysis for us to speak very positively of their value. Action from a distance of a cerebellar abscess is but little, if at all, limited by the pia, and may affect not only any part of the cerebellum and vermiform process, but may extend its influence to the pons and medulla oblongata.

(*c*) *Injuries of the Cerebral Nerves.*—Of these the most common is pressure on the third (oculomotorius), giving paralysis of the upper lid and pupil with ptosis and dilatation—symptoms which are observed in the case of an abscess of the lower (third) temporal lobe; occasionally paralysis of the sixth (abducens) comes from this same cause. Injury of the fifth (trigeminus), producing neuralgia, may be due to pressure on the nerve in its course or to pressure on the Gasserian ganglion from abscess in the temporal lobe. Paralysis of the seventh (facial) may be due to pressure of a cerebellar abscess on the meatus internus, or to pressure on the pons; in the former case the paralysis is on the affected side only; in the latter it may be on the affected side only, or it may be a crossed paralysis on the opposite side, or it may be on both sides, according to the pressure on the pons where the fibres cross.

It must be confessed, however, that in the majority of brain abscesses localizing symptoms are not present, at least in the earlier stages when surgical interference is often of great value, and the surgeon is guided in his search for the abscess by finding the spot where the infection penetrated the skull. This he does by exposing the ear cavities and following the disease inward through the carious penetration of the skull, and thus exposing the dura, through which in many cases a fistula leads directly to the abscess.

Diagnosis of otitic brain abscess is almost impossible in the initial and latent stages; it is often uncertain in the manifest stage unless we are able to build up a connected series of symptoms; in children it is specially difficult on account of the impossibility of making out the nicer distinctions of symptoms. It is comparatively easy when a fistula through the bone leads to the abscess, and this is fortunately the case in a very large proportion of the cases.

As a first help in diagnosis we have a distinct etiological cause in the suppuration of the ear; next, we look for general brain and brain-pressure symptoms. The general brain symptoms are not in themselves of diagnostic value, and only become in a measure confirmatory in connection with other symptoms. Brain-pressure symptoms point to some process within the skull which is diminishing its capacity, and this process in connection with a suppurating ear may be extradural abscess, tumor, or brain abscess. As it is possible for an extradural abscess to press on the cortex of either the cerebrum or the cerebellum, we may have from the extradural collection all the brain-pressure symptoms which exist with a brain abscess except those due to pressure on the internal capsule, and differentiation from these alone is often impossible except by opening the ear cavities and skull. Crossed pareses of the extremities, crossed convulsions, and crossed hemianæsthesia and hemianopsia, if present, point distinctly to abscess. To differentiate an abscess from a tumor, we have, in favor of the former, a distinct etiological cause in the aural suppuration, and more or less fever and a remission of the head symptoms; while, in the case of a tumor, there are an absence of cause, rarely any fever, and a steady increase in the head symptoms without remission. In children tuberculosis of the brain, associated with suppuration of the ear, may render the diagnosis very difficult; but brain tubercles are usually multiple, and symptoms which can only be referred to several different situations point to the presence of tubercles, while symptoms which point to the disease solely in those parts of the brain where otitic abscesses usually lie render an abscess probable.

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* Collins: "Faculty of Speech."

† Hansberg: "Encyclopädie der Ohrenheilkunde."

‡ Collins: *Op. cit.*

Injuries of the cerebral nerves are common with leptomeningitis, not infrequent with brain abscess, and common with tumors, but with extradural abscess they are rare and are confined to the seventh and fifth nerves.

Phlebitis of the Sinuses of the Dura and of the Jugular Vein is less common than simply pachymeningitis, but more common than leptomeningitis and brain abscess. It occurs usually in the lateral sinus, being due to an extension of inflammation from an extradural (perisinous) abscess in the posterior fossa, but it occurs occasionally only in the superior petrosal sinus, in which case it is due to a collection of pus upon either the posterior or the superior surface of the petrous bone; it also occurs, though very rarely, in the inferior petrosal sinus only, and is then due to suppuration in the labyrinth or to caries at the apex of the pyramid. In the case of the jugular vein it is almost always due to extension of phlebitis from the lateral sinus. Phlebitis of the cavernous sinus is always associated with, and caused by extension *ex continuo* from, phlebitis of the lateral sinus. It is not unusual for all of these sinuses, together with the jugular, to be involved secondarily by extension from a primary phlebitis of the lateral sinus. It is rather the rule than the exception for these phlebitides to be complicated with the other otitic intracranial diseases of which pachymeningitis is the most frequent. The bone is diseased in immediate contact with the dura in eighty-two per cent. of the cases (Körner); and the diseased bone is on the inner wall of the mastoid, usually in the sigmoid groove.

Symptoms are dependent upon the stage of the pathological process, upon the phlebitis and thrombosis, upon suppuration of the thrombus, and upon stasis of blood within the brain.

The *phlebitis* alone gives no symptoms; the thrombus may exceptionally obstruct the circulation in the veins which drain into the sinus, but a collateral circulation is so soon established that these symptoms are generally absent. From obstruction of the mastoid emissary we may have swelling and œdema just behind and below the mastoid process; from obstruction of the cavernous sinus we may have congestion of the ophthalmic veins, choked discs, œdema of the eyelids and conjunctiva, protrusion of the eyeball, and congestion of the vena frontalis; and from the periphlebitic swelling we have, very rarely, paralysis of the oculomotorius (third) or of the abducens (sixth), or neuralgic pains in the trifacial (fifth). From obstruction of the jugular there are often cording of the vein, swelling and œdema of the tissues and glands about the vein, and cellulitis of the neck: very rarely, from the periphlebitic swelling at the jugular foramen, there is paralysis of the glossopharyngeus (ninth) or of the pneumogastric (tenth).

The Suppuration of the Thrombus usually gives the characteristic symptoms of the disease. These are generally well-marked pyæmic and septicæmic symptoms; well-defined rigors (one or more); high temperature (104° to 106° F.), remitting or intermitting several times a day, even falling to the normal. Metastatic infarcts are most frequent in the lungs, for the emboli are seldom small enough to pass these organs; but occasionally they are found in the spleen, the joints, or the muscles. Not all emboli are necessarily infected, however, and non-infected infarcts without abscesses occur. Metastatic abscesses in the lungs are usually in the periphery of these organs, and multiple, giving the symptoms of a profuse bronchial catarrh; they often break into the pleura and give an empyema. It is said that non-infected infarcts may produce bloody sputa.

The Stasis of Blood within the Cranium may give headache, either diffuse, or unilateral on the affected side; vomiting, especially in the beginning of the disease; congested papillæ and optic neuritis, although these are not so common as was formerly thought; nystagmus, particularly on turning the eyes away from the diseased ear; psychic depression; and occasionally delirium, but serious disturbances of consciousness are unusual.

Diagnosis.—Pyæmic symptoms, chills with sharp variations in temperature, during a suppuration of the tympanum, either acute or chronic, immediately suggest involvement of the sinuses. Inflammatory symptoms in the mastoid are confirmatory; and if, on opening the mastoid, its inner wall is found to be inflamed and exposure of the dura at this spot fails to discover a large extradural abscess, the diagnosis of sinus disease is almost certain. Cording of the jugular is a sure indication of the disease and occurs, according to Jansen, in one-third of the cases. Leucocytosis I regard as of no diagnostic value, for I have found that it is present in nearly eighty per cent. of uncomplicated tympanic suppurations.

Sinus-phlebitis alone, without other intracranial disease, is found in less than half of the cases; it is usually combined with pachymeningitis and occasionally with brain abscess, and consequently the clinical picture is often bewildering till opening of the bone reveals the path of inflammation from the ear to the sinus. Sometimes a natural cure takes place by a connective-tissue obliteration of the sinus. *J. Orne Green.*

EAR DISEASES: MASTOID OPERATIONS. See *Mastoid Operations.*

EAR DISEASES: METHODS OF DIAGNOSIS.—The condition of each part of the ear may be determined with a fair degree of accuracy after a careful consideration of the subjective and objective materials at hand, notwithstanding the fact that the internal ear is entirely beyond the range of vision and that when it is in its normal condition but little can be seen of the middle ear. The examination of the ear is logically divided into the subjective examination, which includes the history and the tests for hearing, and the objective examination.

The *subjective examination* embraces the investigation into the history of the case and the carrying out of the hearing tests both for the ear as a whole and for the perceptive apparatus alone.

In ascertaining the history of the case it is important to learn what is the most prominent symptom complained of, whether one or both ears are affected, and if both, which of the two seems to be the more seriously involved. In chronic cases, when but one ear is complained of, it will often be found that both are affected though in different degrees. It is well to examine the better ear first so as to ascertain the normal direction and shape of the canal and thus facilitate a comparative test.

The duration of the affection is of importance in determining the prognosis as well as the diagnosis. The shorter the duration the better the prognosis, as a rule. The time of onset may usually be determined with accuracy in the acute cases, for these date from a "cold," from a traumatism, from one of the exanthemata, from typhoid fever, from influenza, from the expansion of a mass of cerumen, or from the introduction of a foreign body or the hatching out of maggots; while in the chronic cases, especially in those belonging to the sclerotic form of otitis media, the disease may, owing to its insidious onset, exist for a long time before its presence is noticed by the patient. The origin in such cases is often dated from the time when the tinnitus made its appearance. In other cases, however, the patient discovers by chance, long after the true onset of the disease, that he is hard of hearing in one ear. Thus, for example, he may, while lying on the good ear, miss certain familiar sounds, as the ticking of a clock. There are cases, furthermore, in which both ears have been insidiously growing hard of hearing for a long time, but in which the patient does not become aware of his deficiency until he finally observes that he has considerable difficulty in carrying on a conversation. In still other cases the patient's attention is first drawn to his ears by the development of tinnitus or by the aggravation of the defective hearing that follows a "cold." In the early stages of hardness of hearing the patient frequently complains of a confusion of words when in company; he can hear one speaker very well, but, when several are talking at the same time, he cannot distinguish the words.

The probable *cause* can in many cases be ascertained from the answers given by the patient, and such knowledge is often a decided aid to diagnosis. The important points to be learned are: (*a*) whether the affection is due to any cause which affects the ear directly, as cold, traumatism, scalds, burns, frost-bite, explosions, fungi, or insects; (*b*) whether it is the sequel of some general malady, as one of the exanthemata, influenza, smallpox, syphilis, tuberculosis, diphtheria, gout, mumps, rachitis, malaria, whooping-cough, or some one of the numerous diseases of the nervous system, the lungs, or the circulatory apparatus; (*c*) whether it is the effect of some drug—usually quinine or the salicylates; or, finally, (*d*) whether it is a result of heredity, which, in the ear as in other diseases, often skips a generation. Unfortunately, there are many cases in which the cause cannot be traced.

Earache or *pain*, if present, is usually the most prominent symptom. If it develops in an ear that has previously been healthy, it indicates the existence of an acute inflammation of the middle ear or a furunculosis of the external auditory canal; if it occurs, on the other hand, during a chronic process, it very probably signifies the spreading of bone caries, or the damming up of pus, or the pressure caused by a cholesteatomatous mass. Pain may at times be purely a reflex otalgia dependent upon carious teeth or upon some inflammatory process in the pharynx or tonsils, or it may in reality be a part of a trifacial or a cervico-occipital neuralgia. It may or may not be present in mastoiditis. Careful observation of the objective signs will often determine the origin of the pain. Thus, for example, pain caused by pressure on the tragus or due to drawing on the auricle indicates an inflammation of the auditory meatus; the presence of tenderness in the depression below the lobule indicates an otitis media; while a tender mastoid indicates the existence of an inflammation in the interior of that bony prominence.

Subjective ear noises (tinnitus aurium) occur in two-thirds of all ear cases, according to Politzer. They are probably due to pressure and irritation of the nerve endings in the labyrinth. Ear noises are variously described as singing, ringing, blowing-off of steam, hissing, rushing, roaring like the waves of the seashore, certain musical notes, clicking, or voices. In some cases the noises are heard only during perfect silence, as after retiring or when the patient is reading alone. They are especially marked when the patient is fatigued, or during a "cold," or when his general condition is below par. Noises are more common in the sclerotic form of chronic middle ear catarrh than in the chronic suppurative conditions. In the sclerotic cases the tinnitus is frequently described as a singing or a blowing sound, and here it often precedes the deafness by many years, if indeed the latter ever follows. Tinnitus may occur in cases of aspergillus or of impacted cerumen, or it may follow the use of quinine or the salicylates. When it is due to drugs it is evanescent and probably is caused by anæmia of the labyrinth. If the noises are diminished by compression of the carotid artery they are probably caused by congestion of the arterioles in the middle or external ear, and in such cases they are often synchronous with the pulse. The clicking or crackling forms of noises are generally due to spasm of the palatal muscles acting on the Eustachian tube and causing separation of its sticky walls. They may also be due to spasm of the tensor tympani or the stapedius muscle. In a certain number of cases these noises may be heard by the examiner as well as by the patient. When the subjective sounds are sustained musical notes they usually represent the high A of Beethoven. Hysterical patients may describe the subjective musical sounds as "entire operas." Voices are rarely heard except in insanity. A small epithelial scale attached to the drum membrane has at times been the sole cause of distressing subjective noises. When the tinnitus intermits the prognosis is more favorable than when it is constant.

Dizziness or *vertigo* is occasionally due to pathological conditions in the ear. This symptom suggests hemorrhage in the labyrinth, especially when accompanied by the chain of symptoms described by Ménière (tinnitus, nausea, vomiting, and depression). Dizziness may be a symptom in any ear disease in which there is pressure upon the membrane of the oval or of the round window, which pressure is in turn transmitted to the nerve endings. Thus, fluid in the middle ear may be a cause, or there may be increased tension of the ossicular chain in consequence of adhesions or of an increase in atmospheric pressure upon the tympanic membrane (from occlusion of the Eustachian tube). Vertigo has also been set up by syringing the ear, or by pressure made with a probe upon the free stapes, or by inflation of the middle ear. Vertigo may be a symptom of meningitis with ear involvement. It must be remembered, however, that vertigo from brain or other lesions may coexist with an independent affection of the ear. Impacted cerumen has been known to cause vertigo.

Discharge.—The character and duration of a discharge are important diagnostic factors. The discharge may indicate an otitis media, a furunculosis, an otitis externa diffusa—either simple or complicated by aspergillus,—or a fracture of the temporal bone. Should the onset of the disease be sudden, as after a cold, bathing, or one of the acute diseases mentioned above as causes; should it be accompanied by pain and by a clear or blood-streaked serous discharge; and, finally, should the pain cease as the discharge begins, an acute otitis media may rightly be suspected. A discharge that commences without pain and becomes purulent in character, indicates a tuberculous condition, especially if multiple perforations of the membrana tympani are found. The quantity of the secretion varies greatly in different cases. Thus, in diffuse otitis externa or in furunculosis it is usually slight in quantity, while in scarlet fever, in diphtheria, in influenza, in bone caries with granulations, and in mastoiditis, it is generally excessive. It is often bloody in the different forms of cachexia, in leukæmia, in cases of traumatism, and in persons in whose ears there has been a post-diphtheritic erosion of an artery. In bone caries the discharge often resembles meat washings, or else it is like serum and irritating in character. In fractures of the base, and at times after operation on the stapes, there is an excessive serous discharge, which rapidly fills the meatus if it is not firmly packed. The presence or absence of odor does not throw any light upon the question whether bone caries is present or not, for the unpleasant smell simply indicates that there is retained discharge which is undergoing decomposition. The discharge may be continuous or it may intermit. Periodical brief discharges preceded by a pain indicate attic trouble, and a perforation of the membrana flaccida should be looked for. The color of a chronic discharge may be modified to any shade and it may contain detritus and numerous cocci, bacteria, and vibriones, together with epithelial scales when cholesteatoma is present. In some cases the objective examination reveals cicatrices, perforations, or adhesions, all of which lesions indicate that a discharge has existed at some previous time. Thus, for example, the small perforations which are found in Shrapnell's region, and which were formerly referred to as the foramen of Rivini, represent the remains of such a pathological process. After long-standing chronic suppuration much destruction of tissue may be expected. Thus, for example, large perforations in the drum membrane, and caries, or even the complete disappearance of the ossicula and neighboring bony parts, may be found.

Other symptoms commonly complained of are: stuffiness and a full feeling or a sensation of pressure in the ear.

In addition to the special points presented above, brief consideration may be given to the more general subjects of *vocation* and *habits of life.* In the case of persons who are exposed to all weathers or who are working in damp, dusty, over-heated, draughty or very noisy places, or who lead sedentary lives or have vicious habits, a more guarded prognosis as to a speedy recovery from ear disease must be given. Auditory nerve lesions are especially apt to be detrimentally affected by noises. It is well to remember that ear affections are more frequent in early childhood and in late life, that they are more common in men than in women, and that the left ear is more frequently involved than the right. About one-fourth of all ear diseases are found in the external ear, sixty per cent. in the middle ear, and eight per cent. in the internal ear. Painful sensations (*hyperæsthesia acoustica*) are sometimes found in nervous people, especially in cases of slowly progressing nerve deafness. *Autophonia* or *tympanophonia* is met with when the walls of the Eustachian tube are swollen or when there is impacted cerumen in the external auditory canal. In this condition the patient's own voice sounds as if he were talking in a barrel.

Paracusis Willisii, or hearing better in a noise, is found more often in the sclerotic form of chronic otitis media and is therefore an unfavorable symptom; *Paracusis localis,* or inability to locate the direction from which a sound comes, is found in marked unilateral deafness. Sudden loss of hearing is a common phenomenon in impacted cerumen, but it also often means labyrinthine syphilis. At times the pitch is altered in one ear; this is an annoying symptom in musicians and usually occurs in disturbances of the inner ear; the affected ear can be detected by holding a fork of known pitch alternately in front of each ear and having the patient imitate the sound. These cases are usually characterized by the circumstance that there is increased pressure upon the stapes in the fenestra ovalis.

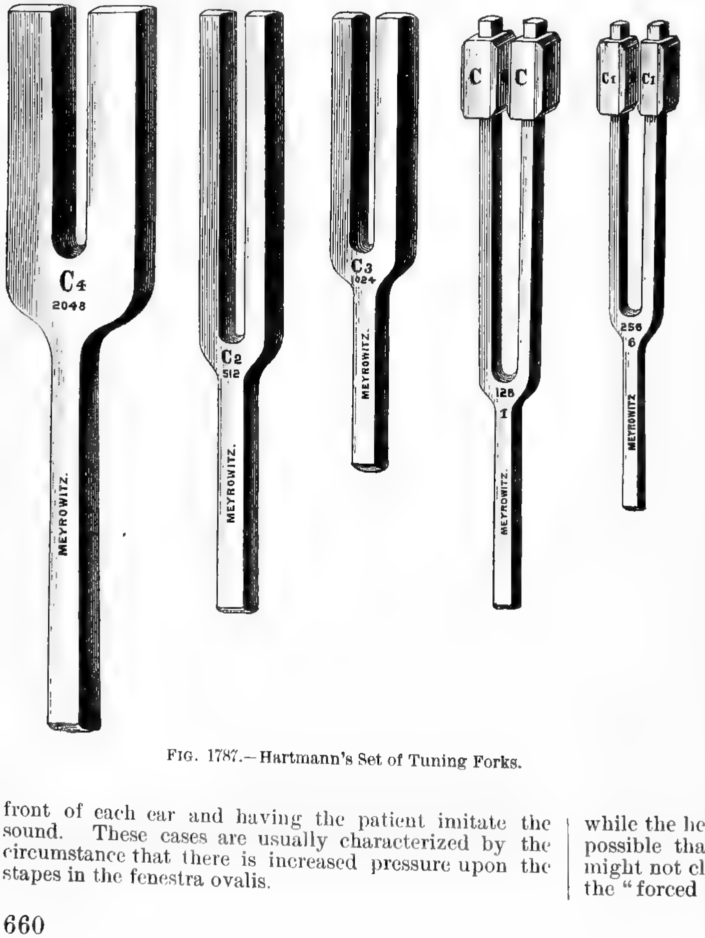

FIG. 1787.—Hartmann's Set of Tuning Forks.

TESTS FOR HEARING.—The hearing should be tested: first, as a whole; second, as to the perceptive apparatus alone. In testing the hearing it is customary to employ the voice (words spoken in the ordinary tone and whispered), a watch which is heard in the normal ear at from fifty to seventy inches, a small clock normally heard from forty to fifty feet, a set of Hartmann's tuning forks, and a Galton whistle. Many other devices have been suggested, some of which are ingenious and of value to the expert. Amongst the latter may be named the universal acoumeter of Politzer, the sonometer of Hughes, the tuning forks of Blake, Lucæ and Dench, König's cylinders, and Appunes' apparatus for determining the upper tone limits, all of which are fully described in the more comprehensive works on this subject. The normal human ear varies in its capabilities of detecting sounds, not only in different people but in the same person under different conditions. As a rule, tones of from sixteen to thirty-three thousand vibrations may be distinguished by the ear, but only those of from forty to four thousand vibrations are pleasing or musical; and the range of musical tones which the voice is capable of producing, is limited to those of from fifty to eighteen hundred vibrations.

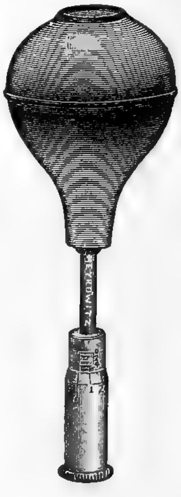

FIG. 1788.—Galton Whistle.

In treating of the hearing power as a whole, we may conveniently consider the subject under the two heads of (*a*) intensity and (*b*) pitch.

Intensity is most conveniently tested by a watch, clock, acoumeter, sonometer, or voice. The voice is useful to the expert, but the beginner will find the watch more practical. Each ear should be tested separately. The one not being tested should be closed by a moistened finger tip, and the eyes should be closed in order to eliminate any psychical element. The patient should first be allowed to hear the character of the sound used in testing, and then the watch should be held in a line perpendicular to the auricle, at a short distance beyond the normal hearing power, and should be gradually approached to the ear until it is heard. The hearing distance is expressed by a fraction the numerator of which is the distance at which the watch is heard by the patient under examination, and the denominator the distance at which the watch should be heard normally; thus A. D. W. D. $\frac{25}{50}$ would indicate that in the right ear the watch distance is one-half of the normal; or, in other words, since sound varies as the square of the distance, that the hearing has been reduced one-fourth. This distance may be expressed in inches or feet. Should the watch be gradually withdrawn from the ear to the farthest hearing limit, the fraction will be greater than when the above method is used, for the probable reason that the nerve endings having once been set in motion tend to continue so, while if at rest they require a louder noise to overcome the inertia and start them vibrating. It must be remembered, in this connection, that the watch may not indicate changes in the hearing power with accuracy, because while the hearing for other tones may be modified, it is possible that hearing for the tones of the watch used might not change. When the voice is used for this test the "forced whisper" from a full chest is best for comparative purposes, and, instead of fixed sentences, numbers of two figures should be used. The phonograph of Gradenigo and Urbantschitsch need simply be mentioned in this connection as having been suggested for this purpose.

Errors in pitch are tested by tuning forks, the Galton whistle (Fig. 1788), and other musical instruments. Hartmann's set consists of five tuning forks (Fig. 1787), as follows:

C.	128	vibrations per second for the pure tone.
C′.	256	" " " " " "
C″.	512	" " " " " "
C‴.	1,024	" " " " " "
C⁗.	4,028	" " " " " "

This set is used by Schwabach in his test. On the other hand, a very accurate diagnosis may be made by using the following instruments: a low-pitched fork, C–1, to determine the low-tone limit (or errors of the conducting apparatus); a higher-pitched fork, as C″, for determining the Schwabach, Weber, and Rinné tests (absolute bone conduction); and the Galton whistle, for determining the upper-tone limits or disturbances of hearing due to disease of the receptive apparatus. The tuning forks should be struck on a moderately soft substance (*e.g.*, wood, covered with leather), in order to avoid the formation of over-tones. The clamps shown on the C and C′ forks are used in order to prevent these. Galton's whistle is employed for the purpose of testing the ability of the auditory nerve fibres to distinguish tones ranging from 6,481 vibrations per second to the highest perceptible tone limit. This apparatus (Fig. 1788) consists of a steel tube of a given size in which air is caused to vibrate by means of a rubber ball fitted to one extremity, while the length of the tube may be regulated by turning the milled head at the other end. The note produced by it will become higher and higher as its length is diminished. In other words, the Galton whistle acts as a closed organ pipe in which the column of air is set in vibration and whose length may be varied at will.

The following rules, although they cannot be trusted implicitly, are of much diagnostic value when taken in connection with other points: 1. In hardness of hearing originating in the conducting apparatus low tones are often lost while high tones are usually heard well. For example, in this form of deafness thunder may not be heard while the voice is heard fairly well. In other words, the low-tone limit is raised. 2. In diseases of the receptive apparatus the high tones are lost or the high-tone limit is lowered while low tones are heard well. In such cases conversation is heard fairly well while the watch is very poorly heard. In certain diseases, in which there is increased pressure on the auditory nerve, both high and low tones may be lost while middle tones are heard fairly well.

By applying the above rules to the results obtained by the forks named (C–1 or Dench adjustable fork for low tones, and Galton whistle for high tones), the condition can be diagnosed.

Testing the Hearing Power in the Perceptive Apparatus Alone.—Among the tests used to determine whether the defects in hearing are due to nerve lesions or to alterations in the conducting apparatus, are those of Weber, Rinné, Gellé, Bing, Schwabach, and Gradenigo.

The *Weber test* consists first in holding the handle of the tuning fork (512 vibrations or lower) on the median line of the skull or against the incisor teeth or the symphysis of the mandible; then, if the vibrating fork is best heard in the deaf ear, the trouble is in the conductive apparatus and if best heard in the better ear the trouble is in the perceptive apparatus.

Rinné's Test.—Rinné first ascertained that the normal ear heard the vibrating tuning fork through the air—*i.e.*, when the fork was held before the ear—about twice as long as when its heel was pressed on the mastoid process—*i.e.*, when the vibrations were transmitted through the bone. He found, however, that when the conducting apparatus is obstructed, the vibrations can be heard louder and longer with the fork in contact with the mastoid than through the air. In the Rinné test, therefore, the vibrating fork is held alternately before the ear and in contact with the mastoid process; and if the sound of the fork is heard louder and longer through the air than through the bone, in a partly deaf ear, it is permissible to infer that the lesion is located in the perceptive apparatus. On the other hand, if, in a similarly deaf ear, the sound is heard better through the bone, it may rightly be concluded that the lesion is in the conductive apparatus. The C″ tuning fork is commonly used for this purpose because if properly made it is free from over-tones. When the loss of hearing is slight the watch may be used, and if its ticking is heard when it is placed on the mastoid, between the teeth, or on the forehead, and not heard in front of the ear (through the air), the defect of hearing—it may be inferred—is in the conducting apparatus.

Gellé's test is for the purpose of ascertaining the mobility of the stapes in the oval window. It depends upon the fact that, if the foot plate is movable, compression of the air in the external canal will cause the sound from a vibrating tuning fork held on the skull to be diminished or lost, while if the foot plate is not movable there will be no change in the intensity of the sound.

Bing's test is a modification of Weber's.

Schwabach's test consists in measuring the actual time of hearing each of the different vibrating forks on the mastoid and before the ear, tabulating these periods of time and applying the rules given above. Schwabach uses, in making this test, the five Hartmann's forks.

In nerve deafness the conduction through air is better than that through bone, although the absolute duration of both is reduced. Bone conduction is usually decreased in the aged, as the auditory nerve is then somewhat defective. In all tests for bone conduction diseases of the external ear should be eliminated by inspection.

The vibrating tuning fork C″ has been used, according to the suggestion of Politzer, as a means of testing the permeability of the Eustachian tube. For this purpose the vibrating fork should be held in front of the nostrils during the act of swallowing. If the sound is then heard better in one ear, the opposite Eustachian tube is probably closed. In this test, however, the fork may be heard better in the worse ear if it happen to be the seat of a sclerotic otitis media with an open tube.

THE OBJECTIVE EXAMINATION.—The objective examination consists of a careful inspection of the periotic region, the external ear, and as much of the middle ear as is visible. This is done with the aid of a strong light and certain instruments of precision, and confirms the subjective examination.

Inspection by the naked eye, aided by concentrated light, should detect any skin lesions (eczema, furuncles, etc.), errors of development, traumatism, tumors or new growths, and variations from the normal color. By the aid of palpation any tenderness, bogginess, or fluctuation may be detected. Tenderness from pressure on the tragus would imply inflammation of the meatus, while the same sensation caused by pressure made below the lobule would point rather to inflammation of the middle ear. Tenderness over the mastoid indicates inflammation in that region. So too palpation is competent to determine the consistence of tumors or swellings. A rigid, cord-like swelling along the anterior border of the sterno-cleido-mastoid muscle is one of the important signs of sinus thrombosis.

Illumination.—Daylight or artificial light may be used, either directly or indirectly. Daylight, when obtained from a light cloud, is excellent, but, inasmuch as it is available only at certain times, it cannot be depended upon. Direct light may be used in the ear in emergencies when there is no mirror at hand, but its value, except for the examination of external parts, is small. Indirect artificial light furnishes the form of illumination most commonly employed. The source of light may be a candle (or, what is better, three candles), a kerosene lamp, gas, or an electric light. The Welsbach light is the better form of gas light. When any artificial light is used allowance must be made for the changes in color due to the source, the reds and yellows being slightly exaggerated in all artificial lights. In practice the light is usually reflected by a centrally perforated concave mirror (Figs. 1789 and 1790). The mirror should be about three and a half inches in diameter and suspended from a head band or a movable bracket attached to the wall. Such a mirror will focus parallel rays at from seven to ten inches. For office work a good combination of light and reflector is that shown in Fig. 1789. In this contrivance the light (Argand, Welsbach, or electric lamp) is condensed by the condensor on the mirror, which in turn focusses the rays upon the point to be examined. The bracket may be raised or lowered by a screw. For bedside work the mirror should be suspended from the headband (Fig. 1790) while the light should occupy a position slightly above the level of the patient's ear and as nearly in the vertical plane that embraces the eye of the observer and the ear to be examined, as is possible without allowing the patient's head to interfere with its rays. The joint that connects the mirror with the head band should be so arranged as to allow the former to be moved in all directions, thus rendering it possible to bring it close to the observer's eye and to turn it in such a direction that it shall throw the rays upon the spot to be examined while yet permitting the examiner's head to remain in a position of ease and comfort. A convenient bedside light is the portable apparatus described by Dench ("Diseases of the Ear," p. 77).

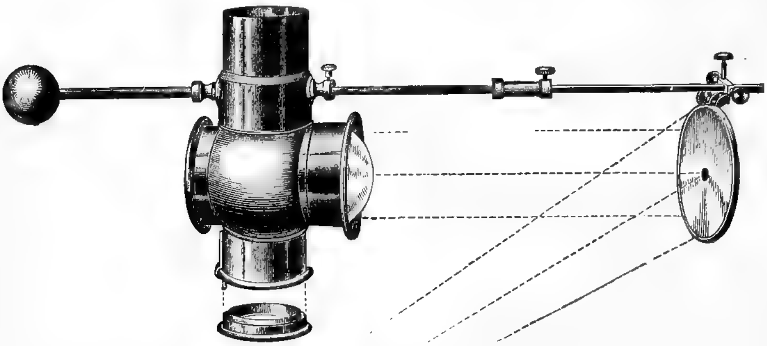

FIG. 1789.—McKenzie Condenser. May be fitted to an adjustable bracket with Argand burner, Welsbach light, or electricity.

A *speculum* of some kind is essential for the thorough examination of the fundus. Specula may be made of various shapes and materials, as pictured in the catalogues of the instrument makers; those which have the largest internal calibre with a given external size being the better. Gruber's specula made of sterling silver, with the small end oval-shaped and the large end circular and milled to facilitate rotation, are very convenient. They have a double longitudinal curve as indicated in Fig. 1791 and may readily be sterilized. The naked-eye examination having been completed the speculum is introduced into the external auditory canal, which is then examined as well as the tympanic membrane and fundus. The better ear should be examined first, for purposes of comparison.

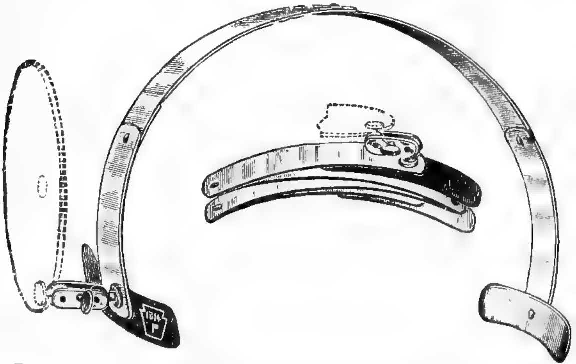

FIG. 1790.—Headband Made of Steel Segments, which fold as in cut or fold over the mirror, thus protecting it.

Introduction of the Speculum.—In the case of an adult the auricle should be grasped between the index and middle finger of the left hand (the index finger in front) and drawn gently but firmly upward, backward and outward, so as to straighten the canal. In children, on the other hand, the auricle should be drawn downward, backward, and somewhat outward, in order to open and straighten the meatus. The warmed speculum should then be gently inserted with the thumb and index finger of the right hand by a rotary motion, care being exercised to prevent its turning up scales of epithelium or detritus in the line of vision. It should be pushed on into the cartilaginous canal as far as possible, but not into the bony part, as this region is exceedingly sensitive to pressure on account of the thinness of its soft parts. In certain cases the presence of the speculum in the canal excites a reflex cough due to irritation of the auricular branch of the vagus (Arnold's nerve) which is transmitted through the superior laryngeal to the muscles of the larynx. Fainting fits or epileptiform convulsions are said to have occurred from the simple introduction of the speculum. The vibrissæ having been pressed aside the state of the meatus may be noted as to size, shape, secretion, and blood supply. The state of the cerumen, whether dry or moist, and the presence of such pathological conditions as seborrhœa, eczema, traumatism, pustules, furuncles, pus, blood, fungi, exostoses, foreign bodies or polypi, should all be noted. Fungi are apt to be overlooked and furuncle must be differentiated from otitis media or mastoiditis. The eye should be over the central orifice of the mirror which should be exactly focussed upon the point under observation. The position of the speculum should be changed from time to time so as to bring each part of the canal and membrana tympani into view. In this examination the eye is aided by a probe made of light tapering steel, the tip of which is barely covered with cotton. The probe enables the observer to remove particles of epithelium, detritus, or cerumen from the line of vision and at the same time to judge of distance, which of course could not be estimated by the single unaided eye. For the removal of large masses of detritus forceps should be used (Figs. 1793 and 1794), and of these at least two patterns should be at hand: one with blades that open in the vertical plane, and another with blades that open horizontally. The various shapes of the normal canal must be borne in mind, and especially should it be remembered that on the anterior inferior wall there is often a decided lump which may nearly shut out a view of the anterior portion of the membrana tympani.

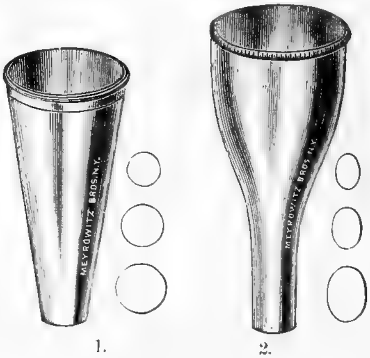

FIG. 1791.—Ear Specula. 1. Wilde's. 2. Gruber's. They are made in nests of three or four, and may be either of metal or of vulcanite.

The appearance of the membrana tympani varies greatly in different subjects, even when the hearing power is normal. The light spot, for example, is blurred in about eighty-six per cent. (Bezold) of healthy ears; the obliquity of the drum membrane is less evident in wide than in narrow canals and less marked in the living than one would expect after seeing the dissected specimen. In childhood the membrane is usually lustreless and in old age it is often gray normally

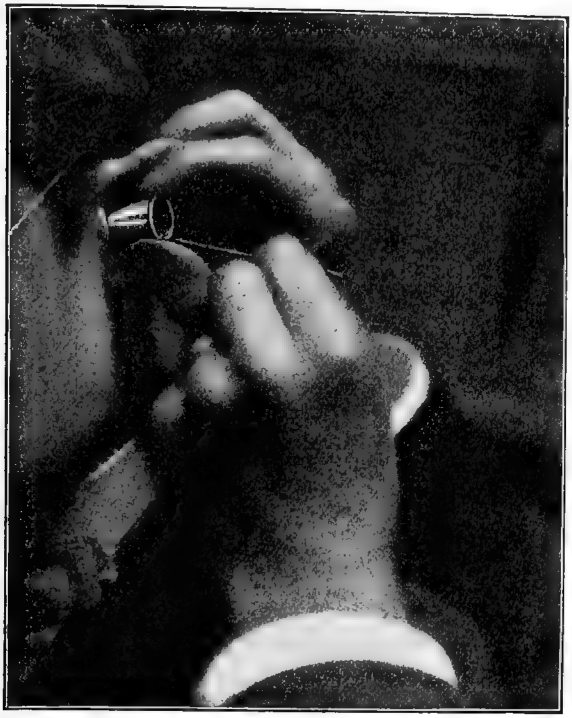

FIG. 1792.—Introducing the Speculum and Examining the Parts by Means of a Slender Probe.

Briefly, then, after the walls of the canal have been surveyed, the eye should be focussed upon the different parts of the membrana tympani in succession: first, the short process and the manubrium mallei should be scrutinized throughout its entire length, and a note should be made of any existing abnormalities; then the peripheral and intervening portions of the membrane should be examined, and in doing this the examiner must not forget that the posterior superior portion is much nearer the observer's eye than is any other portion of the membrane. He should also note carefully its shape, color, lustre, transparency, opacity, and degree of vascularity. The region of Shrapnell's membrane must also be carefully studied and the presence of chalky deposits, perforations, cicatrices, bulgings (from the presence of fluid back of the tympanic membrane), granulations, polypi, etc., must not be overlooked. In the absence of the membrana tympani and ossicles, it is often impossible to tell, by simple inspection, whether one is viewing a congested drum membrane or the mucous membrane of the promontory. This difficulty, which is due to the lack of perspective which exists when only one eye is used, can be overcome only by the use of a suitable probe.

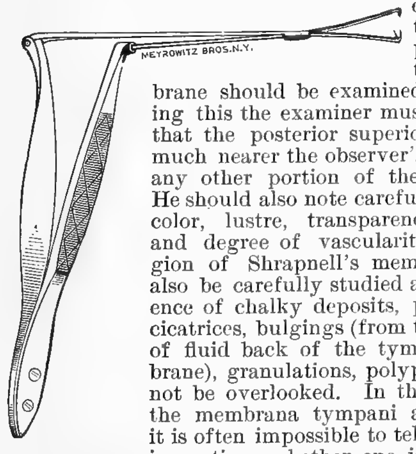

FIG. 1793.—Sexton's Forceps, which may be fitted with various end pieces.

The Siegle speculum (Fig. 1795) will aid one in clearing up many obscure points. It consists of a speculum, the smaller end of which is surrounded by a piece of soft-rubber tubing by means of which it may be inserted airtight into the external orifice of the auditory canal, while the outer flaring end is closed by a plate of glass set obliquely. It has a nipple which projects from its side, and over this is slipped a rubber tube, whose other extremity is attached to a rubber ball or a Delstanche rarefacteur. This instrument should be carefully inserted into the meatus and the air alternately exhausted and condensed by means of the bulb, rarefacteur, or the mouth applied to the tube end.

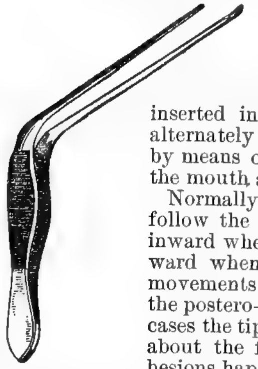

FIG. 1794.—Wilde's Angular Forceps.

Normally, the drum membrane should follow the impulse of the air, moving inward when it is condensed and outward when it is rarefied, and such movements would be most apparent in the postero-superior quadrant. In such cases the tip of the malleus is revolved about the folds as an axis unless adhesions happen to be present, in which case their location is made evident by the absence of the normal movement. Thus, if the tip of the malleus is bound down by intratympanic adhesions, it will evidently not move outward, although there may be bulging of the membrane in front and behind and although the short process may move slightly outward if there is relaxation at that point.

If the ossicular chain and the drum membrane as a whole are drawn inward by extensive adhesions the malleus may be revolved on its long axis.

Frequent observations will acquaint the surgeon with the normal range of these excursions of the various parts of the membrane and the malleus.

The nose and naso-pharynx play a part in the etiology of most diseases of the ear. They should, therefore, be carefully examined according to the rules set down in the proper place in this work.

The naso-pharynx is the vestibule of entry for the middle ear, not only in so-called "colds" but in measles, scarlet fever, diphtheria, influenza, smallpox, pneumonia, and many other diseases. A careful search must therefore be made for stenoses of the nares or naso-pharynx, for hypertrophic or atrophic conditions, and for other abnormalities, such as polypi, exostoses, deflections, etc.; and if irregularities are found to exist they must be corrected before the best results will be obtained in the treatment of ear diseases. Posterior rhinoscopy also furnishes evidence of the condition of the orifices of the Eustachian tubes—whether swollen or atrophied, or whether cicatricial bands are present.

Examination of the Middle Ear.—The presence of evidences of disease in the middle ear and the permeability of the Eustachian tube can be ascertained by the aid of various methods of inflation, which are also at the same time important therapeutic procedures. The methods of inflation are: (*a*) The Valsalva method; (*b*) catheterization, in which bougieing may be included; and (*c*) Politzer's method. In each of these methods—but more particularly in the last two—the nose and naso-pharynx should be thoroughly cleansed, and the Eustachian tube orifices should be wiped out with a curved cotton-tipped

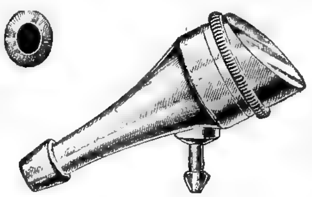

FIG. 1795.—Burnett's Modification of Siegle's Speculum.

probe which has been dipped in glycerol of tannin or iodine and introduced through the mouth and up behind the soft palate.

(*a*) *The Valsalva Method* consists in compressing the air in the naso-pharynx by forcing it up from the lungs when the nostrils are compressed between the thumb and fingers. While easily applied and of some diagnostic value this method is not an entirely safe therapeutic procedure. The entrance of air into the middle ear may be detected by the changes in the appearance of the membrana tympani and especially in the light cone, which may disappear entirely. The malleus often moves outward, and so also does the part of the membrane between it and the periphery. The air passes more easily when there is a perforation in the tympanic membrane.

An *auscultation tube* consisting of a simple rubber tube (Fig. 1796), one end of which is placed in the observer's and the other in the patient's ear, may be used to test the passage of air. As the tympanic membrane bulges outward a short blowing sound reaches the ear of the observer. In cases of perforation of the tympanic membrane there will be a hissing or whistling sound if the air is not impeded in passing through the Eustachian tube.

FIG. 1796.—Auscultation Tube, for Use in Examining the Middle Ear.

(*b*) *Catheterization of the Eustachian Tube* consists in the introduction of a catheter into the pharyngeal extremity of this tube, an operation which is usually accomplished by way of one of the nasal passages, although it may also be effected by way of the mouth. The Eustachian tube may be regarded as a continuation of the inferior meatus of the nose, although the mouth of the tube is usually distinctly outlined by the fold of mucous membrane and the cartilage which bound it above and on either side. At times, however, catheterization is rendered difficult on account of the presence of cicatricial bands, of excessive lymphoid tissue, of posterior turbinated hypertrophies, or of actual polypi. It is at best a most delicate operation and requires a gentle and highly educated touch. The instrument to be used (Fig. 1797) may be made of any metal or of vulcanite, the latter being necessary in cases in which it is desired to apply electricity through the catheter. For diagnostic purposes the catheter made of pure silver is preferable; its tubal end should be well rounded or somewhat bulbous to protect the soft parts, and the outer end should have a milled head, to facilitate the rotation of the instrument, and an eyelet to indicate the direction of the tip. With a metal catheter a larger calibre is obtained for a given outer diameter, and those made of pure silver are more desirable on account of their greater pliability. The catheter must be thoroughly sterilized before and after use, and an instrument which has been used on a syphilitic patient should never be used on other patients.

A number of methods have been advocated for the introduction of the catheter and of these the ones which I am about to describe are, I believe, the most useful. They are named in the order of their relative merit, although any one of them may be necesssary in a given case.

(1) The posterior edge of the vomer is the guiding landmark in Löwenberg's method. The nose and naso-pharynx should be carefully cleansed as above described, the irregularities in them should be noted, and the patient's head should be in a natural vertical position. If the nasal irregularity is great, leaving little room between the inferior turbinate and the septum, or if the patient is nervous and shows a marked aversion to the introduction of the catheter, a cotton-tipped probe bearing a two-per-cent. solution of cocaine may be passed through the inferior meatus to open and anæsthetize it; but the cocaine should not be allowed to reach the mouth of the tube lest the topography be marred. The tip of the nose should be tilted up by the thumb of the operator's left hand, while the other fingers rest for support on the bridge of the nose, or upon the side of the head, as shown in Fig. 1798. The aseptic catheter, warmed and properly oiled, should then be lightly held like a pen, or between the index and middle fingers, with the flaring end resting against the thumb (as shown in Fig. 1798), at an angle of about sixty degrees; then, under good illumination and with great gentleness, the tubal extremity of the instrument is to be steered along the floor of the nose while the shaft is allowed to rest upon the floor of the vestibule. When the tip reaches the pharyngeal wall, or is felt to glide over the velum, it is to be rotated toward the median line and the catheter drawn out until the point is caught by the septum. Then, without further longitudinal motion, the tip is to be revolved downward and outward, through an angle of somewhat more than 180°, when it will be felt to bring up in the mouth of the tube, at about the same time that the eyelet in the outer extremity points to the outer canthus of the eye. The position of the catheter in the tubal orifice may then be verified by a gentle blast from the Politzer bag or from the compressed-air tank. The milled head of the catheter should then be grasped with the thumb and index finger while the other three fingers rest upon the bridge of the nose to steady it.

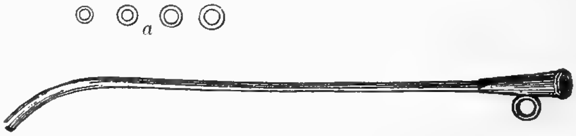

FIG. 1797.—Eustachian Catheter, of Vulcanite or Metal. (About one-half natural size.) Several sizes are available, as shown at *a*.

(2) In the second method the catheter is introduced in the same way as in the first until the pharyngeal wall is reached, when the tip is turned outward into Rosenmüller's fossa and the instrument gently drawn out until it is felt to slip over the posterior lip of the Eustachian orifice, into which it may then readily be turned. This method is not entirely sure or easy to carry out when the

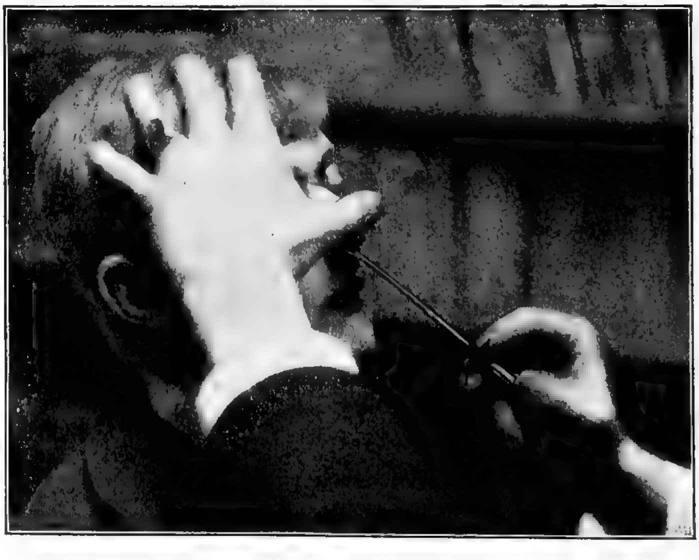

FIG. 1798.—Introduction of the Catheter.

posterior lip is small or flat, as sometimes results from ulceration or from atrophy, or when the anatomical relations of the nose or pharynx are such as not to allow of the tip of the catheter being drawn along the pharyngeal wall. This procedure is also difficult to carry out in the presence of œdema or when there are adenoids, polypi, or hypertrophies of the posterior turbinates. The posterior lip of the tubal orifice may at times be so prominent that the catheter cannot be slipped over it, and in other cases the beak of the instrument may be drawn too far forward and thus pass in front of the anterior lip.

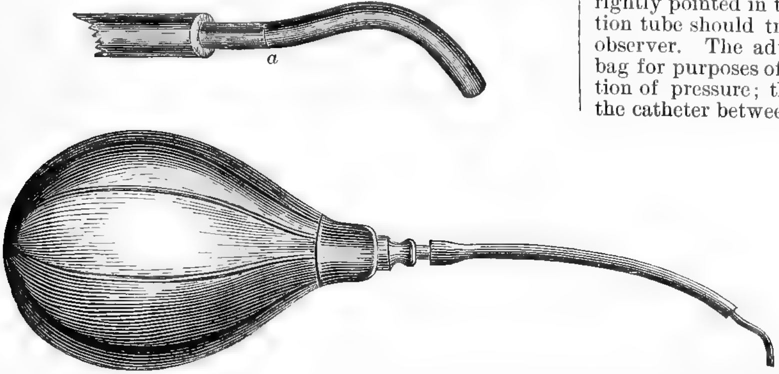

FIG. 1799.—Politzer's Apparatus, complete (one-third natural size). *a*, Nosepiece (natural size).

(3) A third and rather uncertain method consists in introducing the catheter as before until the pharyngeal wall is reached, when the instrument is drawn outward about three-quarters of an inch and the point turned from its downward position through an angle of about 135° until it enters the pharyngeal mouth of the Eustachian tube. It will be readily seen that adenoids, atrophy, or any irregularities of the pharyngeal wall would entirely eliminate accuracy from this method, which is in far too common use.

(4) The expert often introduces the catheter in the manner stated above, gently turning the point outward before the pharynx is reached, and thus lightly guiding it into the tubal orifice by the sense of touch upon the outer wall of the meatus and the pharynx without stopping at any special landmark. This, of course, can be done only with highly educated fingers.

(5) In certain cases, it may be necessary to catheterize through the opposite nostril. For this purpose a more acute angle is given to the tip of the catheter, which is then revolved into Rosenmüller's fossa, drawn over the posterior lip of the tubal orifice, and pressed into the ostium tubæ.

(6) If both nares are occluded, or in cases in which there is a cleft palate, a catheter with a special bend for the case at hand may be introduced through the mouth into Rosenmüller's fossa and slipped over the posterior lip. A two-per-cent. solution of cocaine wiped over the back of the velum may aid in this little operation, which, fortunately, is rarely necessary.

After the catheter has been successfully introduced, air is sent through it into the middle ear by the aid of a Politzer bag or a tank containing compressed air.

The pear-shaped *Politzer bag* is made of soft rubber and should have a capacity of about eight ounces; it should have no valve, and the outlet should be spherical so that the opening may be brought over the end of the catheter without the nozzle or end-piece slipping into the catheter. Jamming and consequent jarring will thus be avoided. An ingenious attachment has recently been invented for regulating the pressure of the compressed air as it comes from the tank. Owing to this invention the Politzer bag has been superseded to a great extent as a means of forcing air through the catheter. Air, chloroform, or iodine vapor may be forced into the catheter from the bag or tank. At first this should be done gently, in order to preclude traumatism and consequent emphysema; but afterward several blasts should be given in quick succession. If the Eustachian tube through which the air is thus forced is patulous and the catheter is rightly pointed in the ostium, clear of folds, the auscultation tube should transmit a clear sound to the ear of the observer. The advantages of the tank over the Politzer bag for purposes of catheterization are: nicety of regulation of pressure; the cut-off need not be removed from the catheter between the successive blasts, as is necessary when the Politzer bag is used, and hence unnecessary jarring is avoided; the air may be heated or medicated when the tank is used; a steady current may be kept up if deemed advisable. The patient's own sensations are not always accurate as to the passage of air into the middle ear. In such cases the auscultation tube or a manometer may be used. To use the auscultation tube intelligently one must be familiar with the blowing sound (bruit de pluie) which is transmitted to the observer's ear in normal cases and its many modifications.

(*c*) *Politzer's Method of Inflation.*—Politzer's method does away with the catheter and has not the disadvantages of Valsalva's method. In fact it may be regarded as the routine method, the use of the catheter being restricted to obstinate cases in which Politzer's is not effective, or to those in which it seems desirable to pass medicaments or the bougie through the instrument. The end-piece originally recommended by Politzer and still preferred by many otologists is that represented in Fig. 1799, *a*. Other authorities give the preference to a straight or an olive-shaped end-piece. For young children the latter pattern is unquestionably preferable. A rubber tube eight or nine inches in length serves to connect the end-piece and the bag. This method of inflating the ears depends upon the compression of the confined air in the naso-pharynx, which air is forced in the direction of least resistance into the Eustachian tubes. In this method the end-piece or nozzle is entered into one naris and both nasal orifices are then closed anteriorly by compression between the thumb and fingers while the naso-pharynx is shut in by approximating the palate against the pharyngeal wall. The latter is accomplished by the act of swallowing, by pronouncing certain words as "huck" or "hock," or by puffing out the cheeks balloon fashion. When swallowing is the method employed, only a small quantity of water is used and the bag is compressed at the moment the pomum Adami is seen to rise. The soft palate, during the act of swallowing, is closely pressed against the pharyngeal wall and the Eustachian tubes are drawn open by the palatal muscles. Previous to compressing the bag the patient should be warned of the shock to be expected, and, in order that it may be as slight as possible, the Politzeration should be done very gently at first. The air will often enter both ears

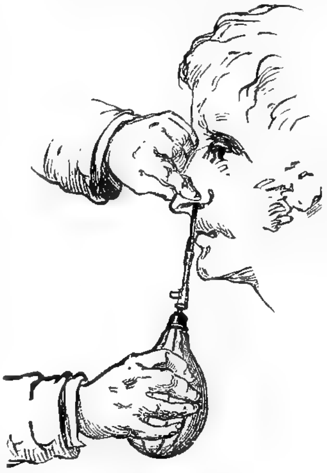

FIG. 1800.—Politzer's Method of Inflating the Middle Ear.

when one tube is swollen, but it will enter on the diseased side with less force. Frequently the patient is unable to tell whether or not the air has passed. When chloroform vapor is used a sense of "heat" or "cold" is felt. In children the act of crying, or often the reflex from the impact of the air upon the soft palate, will throw the latter up and thus close the naso-pharynx; in any event Politzeration is more easily accomplished in childhood because the Eustachian tubes of children are shorter and wider than are those of adults.

Many modifications of Politzeration have been suggested. Condensation of air in the external meatus may be useful to discover perforations when other methods fail. This may be accomplished by placing the olive tip of Politzer's bag in the meatus and compressing the bag.

George C. Stout.

EAR DISEASES: NEW GROWTHS.—New growths of the ear may be divided into benign and malignant growths. Ordinary polypi and syphilitic new growths are dealt with elsewhere in this series of articles and will not be included in the present one.

Benign New Growths of the Auricle.

The benign new growths comprise (1) fibroma or keloid, (2) lipoma, (3) atheroma, (4) cysts, (5) angioma, and (6) papilloma; while the malignant growths include (1) carcinoma, (2) sarcoma.

Fibroma is probably the most common new growth of the auricle. Those which have come under the observation of the author have been unilateral, and Dench holds that this is the rule, while Politzer claims that they are almost always bilateral but of different sizes in the two ears. They usually occur in the lobule, although cases have been reported in which fibromata filled the concha and partly occluded the external meatus (Habermann: *A. f. O.*, Bd. ix., p. 294; and Bürkner: *A. f. O.*, Bd. xv., p. 58).

Etiology.—A very common cause of fibroma is the piercing of the lobule for, and the wearing of, earrings. These growths are more common in the negro race.

Pathology.—They are usually smooth and hard to the touch and vary in size; Agnew and Turnbull having reported cases in which the growths were larger than the auricle itself.

Microscopically, they consist of white fibrous tissue, in which, as a rule, there are very few cells. Anton, however, reported a case in which the growth was soft and contained many cells and leucocytes. Buck examined a specimen of fibroma under the microscope, after its second or third recurrence, and found it to be composed entirely of fibrous tissue. These growths do not recur if thoroughly extirpated.

Agnew reported an interesting case of fibroma which recurred with regularity after repeated removals. Finally it changed its character and appeared as a myxo-fibroma. Strawbridge (Trans. Am. Otol. Soc., July 2d, 1875) reported a case of fibro-chondroma following the irritation of earrings. Haug (*A. f. O.*, Bd. xxxii., p. 161) reported a lympho-fibroma of the tragus in a child of twelve years of age; this growth was as large as a cherry and pedunculated. The keloid cicatrices and myxo-fibromata are next in frequency to the true fibromata.

Treatment.—Thorough extirpation of the growth is the only proper plan of treatment. The incision should be made through healthy tissue, the auricle being cut through and through, and the edges of the wound stitched together. Or, if the growth be large, the lobule should be removed entire without any attempt being made to save the edges. Disfigurement should be guarded against, so far as this may be done consistently with the absolute extirpation of the tumor.

Lipoma.—Kipp (Trans. Am. Otol. Soc., vol. iii., part 3) has reported a case of fibro-lipoma of the concha.

Atheroma.—While atheroma is not strictly a new growth, it may be conveniently considered under this head. These tumors are really sebaceous cysts (wens, milium, or steatoma). They usually occur in the lobule, or at the juncture of the auricle with the head, although Moran reported a case in which the tumor was seated in the concha.

The cause is the blocking up of the duct of a sebaceous gland, causing the retention of sebum in the fundus of the gland and the consequent formation of a cystic tumor which may attain any size. If the growth should be rapid the sac may undergo a rupture, and there may be a history of recurrent discharge, which, if infected, becomes purulent. The outlet for the discharge may be situated in front of, or behind, the lobule. The contents of these sacs consist of sebum, degenerated epithelial cells, and at times cholesterin crystals. As a rule, the deformity caused by the presence of the tumor is the only symptom complained of, unless traumatism be superadded.

Treatment.—A linear incision should be made over the central part of the tumor and then the sac should be carefully dissected out. If it should be ruptured, some difficulty may be experienced in enucleating it in its entirety; but, if it should remain unbroken, the removal may easily be accomplished by the aid of a pair of strong dissecting forceps. In the case of a timid patient, the author has evacuated the contents of the cyst and then has drawn the cyst wall through an incision less than one-quarter of the diameter of the growth. The removal effected in this manner was not followed by a recurrence.

Cystoma.—These tumors are less common than those of the atheromatous variety. Under this head Hartmann classes effusions of serum in the auricle which are due to degenerative changes. Though these effusions are probably due to some old forgotten traumatism, it is often impossible to fix the cause in a given case. Dentigerous cysts should come under this head. The only symptom complained of is the deformity, unless there has been a contusion. Cystomata are usually located on the anterior aspect of the auricle, although they sometimes occur posteriorly. They do not contain blood as do the hæmatomata. They usually appear suddenly and have no tendency to increase in size.

Treatment.—A cystoma should be incised along the natural folds, and horsehair or gut drainage should be introduced. If the tumor is of large size, it may be incised anteriorly and its contents thus evacuated. The incision should then be carried through and through the cartilage; after which the anterior incision should be sewed up and allowed to heal by first intention, while subsequent drainage is continued through the posterior wound.

Angioma.—Angioma, or nævus, is a congenital hypertrophy of the vascular tissues of the corium and subcutaneous tissue. Growths of this nature may be flat or elevated, single or multiple; they may occur in any part of the auricle or its vicinity, and as a rule they present a bluish-black color. They are usually congenital, though Kipp has reported a case following freezing of the auricle. Their growth may be slow or rapid, and they may extend to the meatus or to the skin in the neighborhood of the auricle. When the growth is rapid there may be pain, but usually this symptom is absent. Intercurrent hemorrhages sometimes occur. They are due to the rupture of the walls of a blood-vessel which has undergone atrophy through pressure. Jungken has reported such a case which terminated fatally.

Treatment.—The treatment depends upon the size and character of the growth. If it is small and flat, coagulation of the contained blood and shrivelling of the growth as a whole may be effected by passing through its substance several aseptic silk threads which have been dipped into chloride of iron solution. If the tumor is pedunculated it may be caused to undergo atrophy by encircling the peduncle with tensely drawn india-rubber bands. In the case of larger growths the actual cautery, cautiously used on successive occasions, has been employed with marked success. Electro- or thermo-cauteries, heated to a red heat, are preferable for this purpose, although a large darning needle or similar instrument may be employed, as was done by the author in a case in which no other instruments were at hand. Dupuytren and Weinlechner have effected cures by resorting to the rather heroic method of ligating the carotid artery. When confined to the auricle these growths may be dissected out and the vessel secured while the growth is surrounded by a clamp similar to that used in operations on the eyelids.

PAPILLOMATA, or warts, are at times encountered on the auricle. They are usually slightly pedunculated, long and narrow, and may be readily removed by a cold wire snare; the point of attachment should be touched with a solution of silver nitrate (sixty grains to the ounce) to prevent recurrence. Buck has reported an interesting case of "cornu humanum" which developed as a result of excessive manipulation, parings, etc., of one of these growths by the patient. In the course of two years this horn attained a height of three-quarters of an inch and a breadth, across the base, of the same measurement. Dr. Buck excised the growth by a wedge-shaped incision which removed it in its entirety, and there was no recurrence. Burnett, Pomeroy, Roosa, and others have reported similar cases. Other rare affections of the auricle are hyperostoses, lupus, and calcareous degeneration.

BENIGN NEW GROWTHS OF THE EXTERNAL AUDITORY CANAL.

Benign growths of the external auditory canal include (1) Bony growths, (2) sebaceous cysts, (3) angiomata, and (4) false membranes.

OSTEOMA.—Bony growths are the most frequent benign tumors of the meatus. They are hyperplasias of some part of the osseous external canal and occasion no symptoms *per se*, often being discovered by chance. They may be single or multiple, may be found at the junction of the osseous and cartilaginous portions of the canal, or at any point between this and the tympanic membranes. Those which occur at the junction of the osseous and cartilaginous portions of the canal usually arise from the posterior wall, are more often single, and vary in size from small mounds to spherical masses which fill the canal. They may be sessile (hyperostoses) or pedunculated (exostoses), and they vary in density from ivory-like hardness to the consistence of cancellous bone. They are covered with skin which is thinner than that of the neighboring canal; in the larger growths this thinness is more marked. On account of its tenseness the skin is apt to be more tender over the growths than elsewhere. When small they occasion no discomfort and are often discovered by chance. When they are larger, however, epithelium and detritus are prone to collect in the canal, between them and the membrana tympani, and thus cause hardness of hearing and tinnitus. Their rate of growth is variable and in the early stages it has, for obvious reasons, seldom been observed. Later, however, they have been seen to grow rapidly for a time and then apparently to stop growing without cause. In one case observed by the author the osteoma continued to grow, for six months after it had been discovered, until it entirely closed the canal. This case was operated upon by means of the hand gouge used in mastoid work, and although the growth was situated at the above-named junction, it was found to be exceedingly hard and required forty-five minutes of most careful and diligent work for its removal. The excision of the tumor, which possessed a broad base, gave decided relief to both the tinnitus and the hardness of hearing.

Etiology.—Some osteomata are believed to be of congenital origin, while others are attributed to rheumatism, gout, or syphilis. It is an undoubted fact that these growths often develop in the course of chronic suppurative or non-suppurative processes involving either the middle ear or the external auditory canal. As regards the relation of osteomata to gout and syphilis, it is true that they frequently occur in gouty or syphilitic subjects, but this does not prove that the relationship between them is one of cause and effect; for many other aural diseases develop in such subjects and yet nobody would think of attributing them, for this reason, to either gout or syphilis as a cause. That they occur congenitally is doubtful (Buck) from the fact that at birth the osseous canal is but a ring of bone. On the other hand, it is scarcely doubtful that a chronic inflammatory process or a traumatism is competent to cause the development of an osteoma, for either of these will produce a localized periostitis, and this in turn would be likely to result in the formation of osseous tissue. The theory that polypi occasionally become organized as osseous tissue seems also plausible. A clear history of such an origin in any given case can seldom be obtained. The reports of Sir William Dalby and others imply that exostoses occur more frequently in the better-class Englishmen than they do among the people of this country. They are said to be common in pearl divers and in the natives of Hawaii who bathe excessively, but Wyman found many in the skulls of Peruvians who lived inland.

Treatment.—In many of the recognized cases the treatment is usually restricted to the removal of the cerumen and detritus, by the most gentle means at hand, from that portion of the canal which is situated between the growth and the drum membrane. This may be accomplished by a delicate bent probe, armed with a small whisp of cotton twisted over its end. Syringing may be resorted to, but it is often both ineffectual and undesirable, for it may increase the tinnitus and hardness of hearing. The cleaning process, which is usually tedious, should be carried out in a thorough but gentle fashion. When the growth attains such dimensions as to cause complete occlusion of the canal, thus producing deafness and sometimes distressing tinnitus, or else causing retention of a purulent discharge that is escaping from the middle ear, it should be removed at least in part. This is especially true if bone conduction is good. The only two methods of operation worthy of consideration are: (1) removal by means of the hand gouge and (2) removal by means of dental drills. It is not necessary in either case to dissect off the skin. The mastoid hand gouge is a very effective instrument for the removal of an exostosis when it is located in the external portion of the canal, especially if it is composed of spongy bone. The dental drills are better for the ivory-like growths or for those located deep in the canal, though the operator's familiarity with either method is a factor in the case. Pedunculated growths may at times be readily snapped off by a prying movement of the gouge, as in a case observed by the author. The narrowness of the canal and the fact that the deeper growths are more apt to be ivory-like make the drills preferable for those so located. The shape of the drill is to be chosen according to the conditions present in the case under consideration. The number of revolutions of the dental engine per minute should also vary according to the character of the growth. The hemorrhage from these operations is usually slight but may at times be embarrassing, as it obscures the field of operation. These operations, which often require much patience, should be done under strict asepsis and with the aid of a general anæsthetic. The after-treatment consists chiefly in the maintenance of strict asepsis, and if there is no discharge from the middle ear the external auditory canal should be packed with gauze in order to prevent the cicatrix from narrowing the meatus. If there is a discharge from the deeper parts, a tube should be inserted for this purpose, as otherwise membranous bands are apt to form which may entirely close the canal.

SEBACEOUS CYSTS.—Cysts of the meatus are of rare occurrence, but they have been occasionally reported. They resemble milium or the sebaceous cysts which occur elsewhere. They vary in size from that of a millet seed to the entire diameter of the canal. When they are small they do no harm, but when large enough to occlude the canal they cause tinnitus, autophony, or deafness; and if they continue to grow, they may cause pressure atrophy or erosion, or may lead to the formation of the "molluscous tumors" mentioned by various writers (Toynbee, Kirk and Duncanson, and others). They have been known to suppurate. They are more often found in the cartilaginous meatus, where the ceruminous glands and sebaceous follicles are numerous, than in the osseous portion.

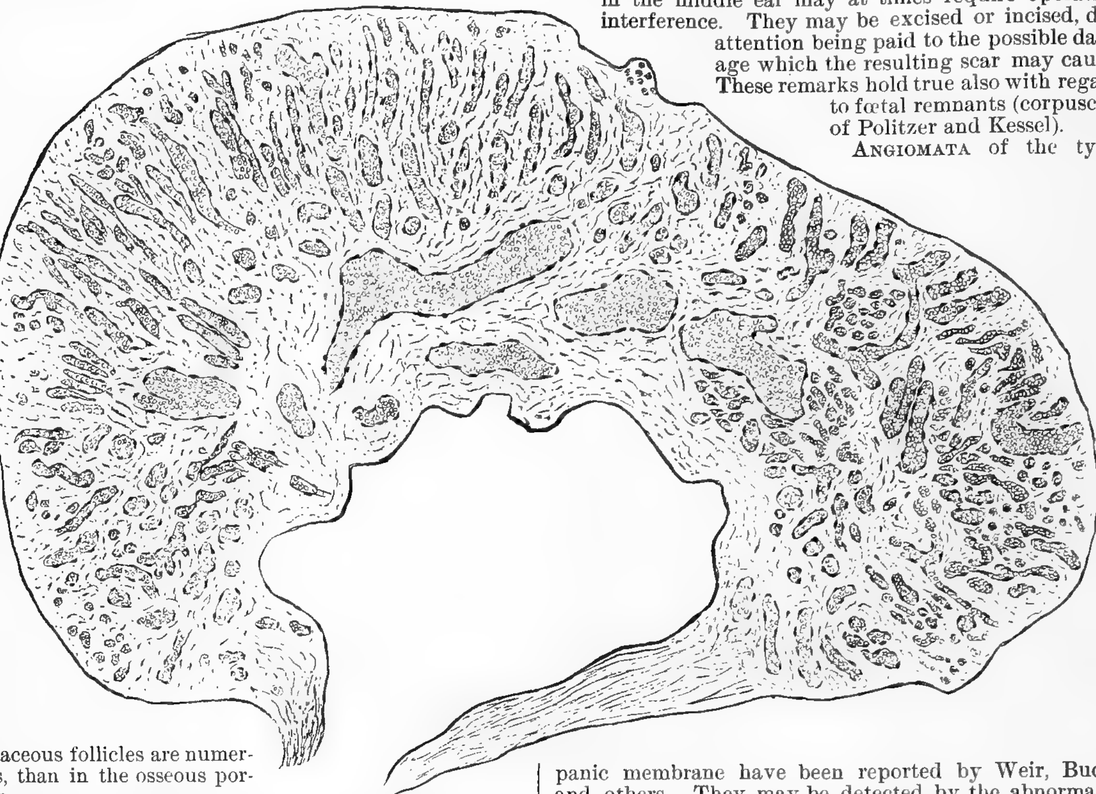

FIG. 1801.—Cross Section of Angiomatous Polypus, as seen under a low power. (Buck's case.) From a drawing made by Dr. Ira Van Gieson.

As regards the pathology of these sebaceous cysts it is sufficient to say that they are simply retention cysts, containing cheesy or atheromatous material.

Treatment.—These cysts should be incised with a small sharp-pointed bistoury, their contents evacuated, and a solution of iodine, potassium iodide, and glycerin applied to the open wound.

ANGIOMA.—A few cases of angioma of the external auditory canal have been reported, and under this head aneurismal tumors like that reported by Todd, of St. Louis (*Amer. Journal of Otol.*, vol. iv., p. 187, 1882), would be classed. As regards their pathology and treatment, nothing need be added to what was stated under the head of angioma of the auricle.

FALSE MEMBRANES or bands are at times found in the external auditory canal, and if they cause symptoms they may be excised or incised, great care being taken to prevent the subsequent narrowing of the canal.

ENCHONDROMA.—A few cases of enchondroma of the external auditory canal have been reported. These growths should be dealt with on lines similar to those mentioned under the head of exostoses.

BENIGN NEW GROWTHS OF THE MIDDLE EAR.

Ordinary polypi, cholesteatomata, and new growths of a syphilitic or tuberculous character will be dealt with elsewhere in the HANDBOOK.

PAPILLOMATA or wart-like growths are at times found on the tympanic membrane;, they are possibly due to the instillation of irritating fluids into the external auditory canal.

PEARLY GROWTHS, according to Gruber, have been found in the tympanic membrane. They consist of cholesterin crystals, epithelial cells, and débris.

GROWTHS COMPOSED OF FIBROUS TISSUE.—Newly formed membranes and bands which are observed in the middle ear may at times require operative interference. They may be excised or incised, due attention being paid to the possible damage which the resulting scar may cause. These remarks hold true also with regard to fœtal remnants (corpuscles of Politzer and Kessel).

ANGIOMATA of the tympanic membrane have been reported by Weir, Buck, and others. They may be detected by the abnormally red appearance of the tympanic membrane or of the growth itself, should the tympanic membrane be absent. Redness may extend over the lower half of the membrane or may present itself in irregular splotches; the membrane itself may be bulged outward from pressure, and it may pulsate synchronously with the radial pulse; tinnitus is often present; and, finally, the hardness of hearing may be extreme. These growths occur at times without apparent cause and develop slowly; they are composed almost entirely of blood-vessels, and if removed by cutting may recur (Buck) (Fig. 1801). Paracentesis may be followed by a severe hemorrhage in which an ounce or more of blood is quickly lost.

The *treatment* consists in the application of chromic acid, the acid nitrate of mercury, or pure nitric acid on the tip of the delicately wrapped cotton carrier; or a small ignipuncture may be made by means of a fine electro-cautery.

Exostoses or ecchondroses of the ossicles have been reported.

Fibroma and osteoma of the middle ear have been found post mortem.

MALIGNANT GROWTHS OF THE AURICLE.

Epithelioma and *sarcoma* are the most common malignant growths of the auricle, epithelioma being far the more common. Minor, in 104,412 ear cases collected in the service of nine American hospitals, found that epithelioma occurred eighty times while there were no cases of sarcoma in this list. This in a measure agrees with the general statistics, which show that epithelioma is far more common than any other malignant growth of the auricle. Cases of epithelioma have been reported by Buck, Orne Green, Gruber, Sacke, Habermann, Burnett, Wilde, Schubert, Kipp, Kramer, Moos, Marian, Kretschmann, Seely, Haug, Bruner, Bryant, Demarquay, and others. So far as one can infer from the accounts of the cases mentioned above, epithelial cancer is much the same when occurring in the auricle as when it involves other parts of the body. In many cases there is at first a wart-like growth, which is subjected to traumatism, scratched, pinched, touched with strong acids, or removed by the knife, and which then grows more and more rapidly the more it is disturbed, until finally the affected part becomes covered with scabs under which will be found ulcers that are more or less deep and that may or may not show a tendency to bleed. There may also be severe pain, but this symptom is not common. More often the patient applies for relief simply on account of a long-standing or obstinate "sore." In some cases, as in that reported by Valpau, the growth seems to have been rapid. Epitheliomata are more apt to occur in those past middle life. They tend to spread to the external auditory canal and neighboring parts of the head. On the other hand, they are often secondary to growths in these neighboring parts. The term epithelial carcinoma is usually applied to these growths, Gruber claiming that this is the only form of malignant tumor which attacks the auricle primarily. When the disease is allowed to spread to the head—the meatus, middle and internal ears becoming affected in turn—death results from debility or from meningeal or brain involvement; the glands of the neck or the parotid gland may also in some instances become involved.

Treatment.—Here as elsewhere the only rational treatment is complete extirpation. All of the diseased and suspected tissues—including the entire auricle, cutaneous walls of the external auditory canal, the lymph glands of the neck, and the parotid gland if necessary—should be removed. If the case is seen early the removal of the growth by a V-shaped incision may suffice. The entire auricle has been removed a number of times, and in one case at least this was done by means of the cautery snare. Dench and others have removed the entire cartilaginous canal. When the operative interference involves the canal, a tube should be introduced and kept in position until the wound is entirely healed; otherwise cicatricial closure is to be feared.

SARCOMA.—Although sarcomata are of relatively infrequent occurrence, they have been reported by Roudout, Stacke and Kretschmann, Schabert, and others. In the case reported by Roudout the growth had existed for twenty years, but its complete extirpation resulted in a cure. In the case of Stacke and Kretschmann the growth was removed by the galvano-cautery snare and the result proved to be an entire success.

MALIGNANT GROWTHS OF THE EXTERNAL AUDITORY CANAL.

Primary malignant growths in this region are more rare even than those of a secondary nature, carcinoma predominating here as in the auricle. Buck reports two cases of secondary carcinoma, one of which originated in the middle ear and the other in the cervical glands behind the ear. Kessel, Delstanche, and others have reported cases of carcinoma. In most cases it is doubtful whether they are primary or secondary. Buck also reports a case of primary sarcoma occurring in the external canal of a young girl fourteen years of age. This latter—an osteo-sarcoma—recurred repeatedly until it was finally thoroughly removed, the neighboring parts having been well scraped, and a strong solution of chloride of zinc applied to the wound.

MALIGNANT GROWTHS OF THE MIDDLE EAR.

Here also the malignant growths which have been reported were, as a rule, carcinomatous in character. Apparently, they occur only rarely. In most instances they develop in the course of a neglected chronic suppurative inflammation of the middle ear or a necrotic process of the temporal bone. They may also appear in the middle ear secondarily to their development in some neighboring part; and this undoubtedly is the more common course of events. These growths usually occur in patients of from forty to sixty years of age.

Symptoms.—These include pain, which is often severe, paralysis of the facial nerve from its involvement in the malignant disease, hemorrhage, which may be frequent and profuse, induration of the cervical glands, meningitis, abscess of the brain, sinus thrombosis, or hemorrhage from the lateral sinus. Death, which is the usual termination, is due to exhaustion or to one of the four events just mentioned.

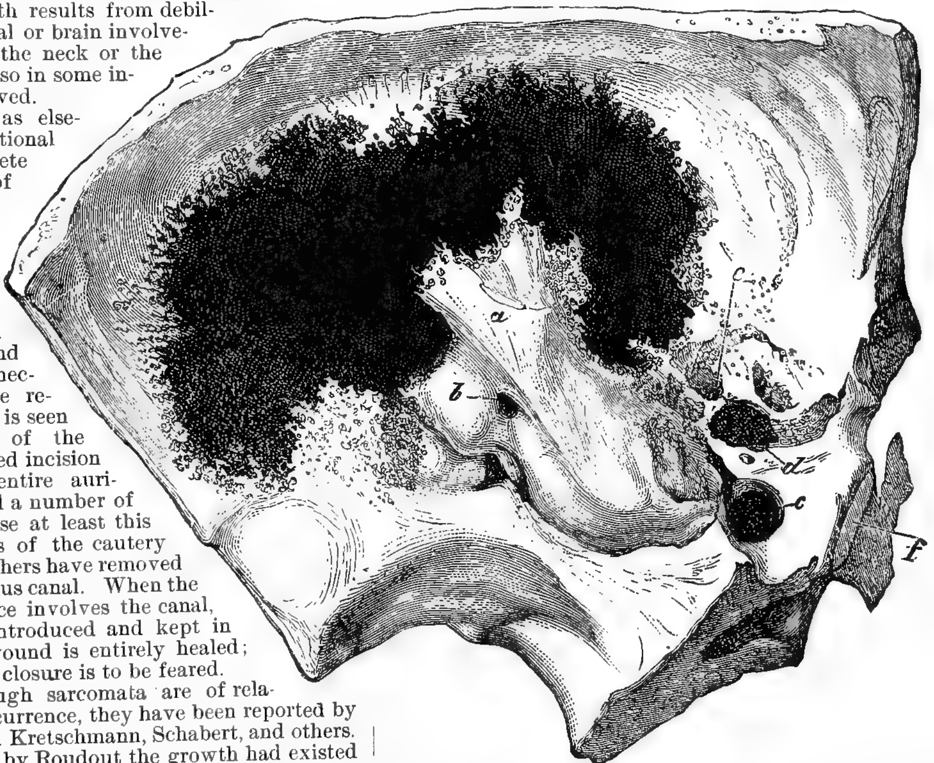

FIG. 1802.—Destruction of the Temporal Bone by Epithelial Cancer. *a*, Median remnant of the pars petrosa; on the surface of its apex the bone is also destroyed by the new growth; *b*, porus acusticus internus; *c*, foramen lacerum anterius; *d*, foramen ovale, enlarged by destruction of its edges to twice its natural circumference; *e*, foramen spinosum; *f*, sphenoid articulation. (After Schwartze.)

Diagnosis.—The gradual development of a malignant growth in the middle ear, in the course of some chronic affection of that region, renders it practically impossible to make a correct diagnosis until the frequent recurrences after removal and perhaps the behavior of the growth in other respects arouse the surgeon's suspicions and lead him to examine the tissues with the microscope.

Treatment.—This is usually palliative only, although as a last resort the mastoid may be opened (Schwartze), in cases in which the disease is pent up in the tympanum or in which it is apparently extending inward.

Sarcoma.—Cases are on record in which sarcomatous growths, both primary and secondary, have been observed in the middle ear. They are more apt to be found in childhood, and are usually of rapid growth. In their early stages they generally resemble ordinary polypi, but, unlike them, they recur quickly after repeated excision. As in the case of carcinomata they are apt to follow chronic inflammatory conditions. The discharge may be bloody, very offensive, and purulent. In the later stages there may be paralysis of the facial, the abducens, or the first division of the fifth nerve, in association with meningeal or brain symptoms or severe hemorrhage from erosion of the large blood-vessels in the neighborhood.

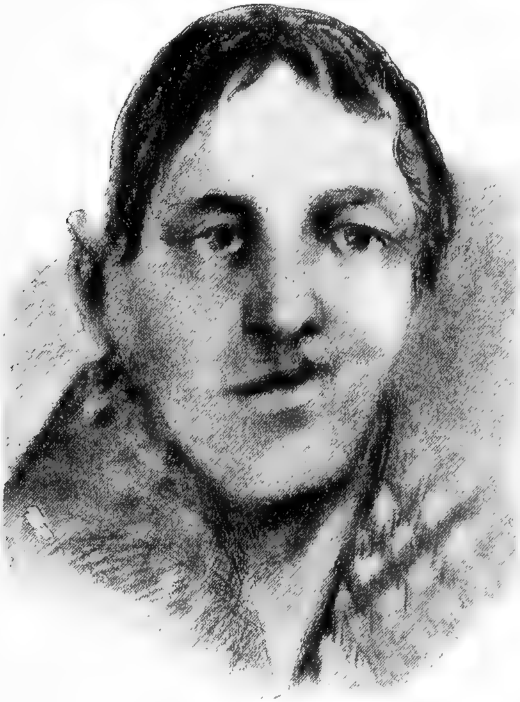

Fig. 1803.—Carcinoma of the Temporal Bone. (Case of Dr. Gorham Bacon.) From a photograph.

Malignant Growths of the Internal Ear.

In the labyrinth, as in the middle ear, malignant new growths are more apt to be secondary than primary. Very few of the cases of primary growth in the labyrinth have been fully enough reported to possess any clinical value. Sarcoma, neuroma (glioma), and carcinoma have been reported. Virchow has shown that the auditory nerve is more often the seat of new growths than is any other of the cranial nerves. Politzer reports a case of carcinoma of the labyrinth in a man aged forty-seven years. In this case the growth originated in the mastoid region, spread through the middle ear to the cochlea, and thence through the internal meatus to the brain. Death occurred through erysipelas. New growths, however, are more apt to reach the auditory nerve and labyrinth from the cranial cavity, and in most instances they are primarily carcinomata of the dura or of the brain itself. Burkhardt-Merian (*A. f. O.*, Bd. xii.) reported the finding, post mortem, of a fibro-sarcoma in a man, aged sixty-six, who had died of pneumonia. This had originated in the termination of the inferior petrosal sinus and had passed thence by two tracks into the labyrinth—one through the aquæductus cochleæ and the other below the internal auditory meatus, around the cochlea, to the tunica adventitia of the carotid artery. Field has reported a sarcoma, the size of an orange, on the posterior surface of the petrous bone, which had originated in the dura and had destroyed the auditory nerve.

Moos (*A. f. O.*, Bd. iv.) has reported a case of spindle-cell sarcoma which was as large as a walnut and situated externally to the left internal auditory canal. It was connected with the cerebellum and pushed the medulla oblongata over toward the right; the auditory nerve entered into the tumor but was speedily lost among its component tissues; and a second tumor, the size of a pea, was found in the dilated internal auditory canal. The cervical and dorsal portions of the spinal cord were degenerated, as was also the labyrinthine portion of the auditory nerve. This case occurred in a woman, aged forty-five, who died of suffocation one year after a sudden attack of vertigo, deafness, ptosis, lachrymation, and headache. *George C. Stout.*

EAR DISEASES: OPERATIONS UPON THE TYMPANIC MEMBRANE AND OSSICLES.—Operations upon the drumhead and ossicles and within the middle ear are usually done through the natural channel of the external auditory canal; when this canal does not permit a sufficiently free access to the operative field, it is necessary to reflect the auricle forward by means of a curvilinear incision through the integument and underlying soft tissues; this necessity is a comparatively rare occurrence, for, even when the external auditory canal is much narrowed, it is possible, under good illumination and with the exercise of an educated tactile sense, to do the majority of middle-ear operations through the natural channel.

In all operations involving the opening of the tympanic cavity, especially those applied to the relief of conditions incident to non-suppurative disease, sterilization of the canal, of the auricle, and of such parts of the head and neck of the patient as may come in contact with the hand of the surgeon, is an important prerequisite. To this end, the auricle, and the skin about it, should be thoroughly washed with soapsuds (green soap) and afterward with alcohol, and, if the sterilization is done the night before operation, the parts mentioned should be covered with dry baked gauze; at the time of operation, a sterilized towel should be pinned over the head and another over the neck and shoulders of the patient. The external auditory canal should be carefully cleansed of cerumen and epidermis, preferably by means of a moist, cotton-tipped probe, and this should be followed by a similar swabbing with either the peroxide of hydrogen or alcohol, care being taken, if this cleansing is done shortly before operation, to avoid maceration of the outer coat of the drumhead, or to increase unduly the circulation. In emergency operations, such as incisions for phlebotomy or to give exit to fluid, when the more thorough precautions of sterilization are not possible, it is still important to have the hands of the operator and the instruments and dressings which he uses sterile, and to avoid contact of the former with the patient and of the instruments with the walls of the canal.

The simple operation of incising the drumhead is usually done for the purpose of relieving blood pressure or of evacuating the fluid contents of the middle ear, contents which may vary in quantity from a few drops to a body of fluid sufficing to fill the whole tympanum, and in consistence from the thinness of fresh serum to the thickness of inspissated mucus.

The point usually chosen for paracentesis, for the evacuation of fluid, is the posterior inferior quadrant of the drumhead, the incision varying in size from that of a simple puncture to a cut of two or more millimetres in length made from below upward and parallel to the peripheral line of the drumhead. For purposes of phlebotomy, in cases of acute congestion in the epitympanum, the incision is usually made along the posterior superior periphery, from below upward, ending at or near the short process of the hammer and capable of penetrating to the deeper layer of blood-vessels in the inner tympanic fold.

After incision, in such cases, the ear should be wiped dry and plugged at the meatus with a piece of sterile cotton, or the canal should be filled with a loosely rolled absorbent cotton wick extending as far out as the entrance of the canal; over this and filling the concha, a second piece of cotton should be placed, directions being given for its renewal when thoroughly moistened by the outflow from the ear, fresh cotton then being applied externally but the drainage wick being allowed to remain in place for several hours at a time and changed only under conditions of careful sterilization of the hands which roll the wick and of the instruments which introduce it.*

If the fluid to be released from the middle ear is thick and tenacious, a larger incision in the drumhead is required than when it is thin and flows freely; evacuation may be assisted by auto-inflation of the middle ear, by Politzerization, by the use of the catheter, or by means of the pneumatic speculum and suction. When the secretion is so thick that only a small bead-like portion extrudes, this may be touched with a weak solution of nitrate of silver on a cotton-tipped probe, the resulting coagulum affording a hold to the forceps by means of which the tenacious mass may be withdrawn.

Forcible inflation of the middle ear after paracentesis for the relief of acute congestion or the release of the products of acute suppurative inflammation is contraindicated.

In the two classes of cases demanding the more extensive operations upon the drumhead and within the middle ear, the operations are more distinctly differentiated in their purpose than in their method of procedure.

In suppurative middle-ear disease, operation is usually undertaken with a view to affording exit to morbid products and permitting access to diseased parts for purposes of removal or of curative application, the betterment of the hearing being a secondary consideration. In non-suppurative middle-ear disease, operative interference is usually undertaken as a measure of last resort, for the relief of a high grade of impairment of hearing or of the concomitant symptoms due to immobility of the sound-transmitting apparatus in the middle ear.

In all middle-ear operations, but especially, of course, in non-suppurative cases, conditions of sterilization should be strictly observed, and the more uniformly these are insisted upon by the surgeon, both for himself and his assistants, the more definitely do they become fixed as an important and necessary habit.

A common result of suppurative middle-ear disease is a persistent opening in the drumhead, and if the middle ear has become dry and the mobility of the ossicular chain is comparatively unimpaired, closure of the opening effects an improvement in the hearing. This is easily tested by covering the perforation with a disc of moistened paper, and if the result is favorable, the paper may be used to assist in the permanent closure of the opening.

The edge of an old perforation of the drumhead consists of a thin line of cicatricial tissue or of a union of the outer, dermoid, and inner, mucous coats in the form of a transition membrane; both of these structures are inimical to proliferative growth and must, therefore, be removed. This is done preferably by means of a thin-bladed knife, the cut edges are then wiped dry, and a disc of thin, sized paper is floated and moistened in a weak corrosive solution, picked up on a cotton-tipped probe, and gently applied over the opening; immediately upon contact with the dry, warm surface of the drumhead the paper leaves the wet cotton tip and adheres to the membrane. By this manipulation and by patting with a dry, cotton-tipped probe adhesion is favored and the superfluous moisture is absorbed. Inflation of the ear for at least twenty-four hours after application of the paper should be avoided.

The stiff, adherent paper not only pulls upon the rim of the perforation with every major vibration of the drumhead, causing an irritation which stimulates new growth, but serves as a protection and a guide along which the nascent tissue progresses. This application has been found serviceable not only in the healing of smaller perforations (one dressing alone sometimes sufficing), but also in the building up of larger cicatrices when a principal portion of a drumhead has been destroyed, and when it has been necessary to apply the paper to successive portions of the perforation rim and to occupy several months in the entire healing.

As after-results of suppurative middle-ear disease, there may be thickening of the mucous folds in the epitympanum, the formation of adhesions limiting the movements of the ossicles, and of cicatricial membranes growing inward from the edges of the perforation of the drumhead and interfering with the transmission of sound. The common locations of adhesions are between the long process of the malleus and the inner tympanic wall and around the stapes and into the fenestral niche, while the thickening of the reduplications of mucous membrane, normal in a large majority of middle ears and often filling the lower limit of the epitympanum, serves to keep the ossicles in the abnormal position into which they are drawn by contraction of the tensor tympani muscle exerted when the counter-balancing tension of the drumhead is removed by perforation.

The extension of a cicatrix from the posterior edge of a large perforation of the drumhead inward upon the inner tympanic wall will sometimes enclose the round window in an individual space. Under this condition, absorption of air in the enclosed space or the exudation of fluid into it will so far impair the movement of the membrane of the round window as to still further decrease the hearing, puncture or incision of the cicatrix being required.

In all tentative operations for improvement of hearing by division of adhesions and mobilization of the ossicles, if the suppurative process has run its course and the ear has become dry, it should be remembered that there is a possibility of awakening acute trouble, and that, unless complete evulsion of the larger ossicles is intended, mobilization had best be gradually effected in successive stages, and preferably without general anæsthesia, in order that the effect upon the hearing may be progressively tested.

In a case, for instance, of a large perforation of the drumhead with the tip of the malleus adherent to the promontory and adhesions or cicatricial bands obstructing the movements of other members of the ossicular chain, the first step should be the division of the adhesions at the tip of the malleus and gentle mobilization of that bone by means of a blunt hook. If it is decided to suspend interference at this point, the middle ear should be carefully dried and lightly packed with sterile, absorbent cotton, a dossil of cotton being placed behind the malleus to prevent recurrence of adhesion. At subsequent sittings, other bands and adhesions should be divided, circumcision of the stapes done, and tenotomy of either the tensor tympani or the stapedius muscles. It is occasionally possible, in cases of ankylosis of the ossicles, without fixation of the stapes, to utilize the ossicular chain as a columella by dividing the tendons of both the stapedius and tensor tympani muscles, and inserting an artificial drumhead.

If the chronic suppurative disease is in progress, and there are present the redundant granulomata which almost invariably indicate the existence of areas of necrotic bone, such surfaces should be carefully sought for and curetted either by means of the cup-shaped middle-ear or wire-ring curettes.*

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* A convenient method of preparation and of carrying sterile absorbent cotton to be used for these and similar purposes in middle-ear operations is to roll the cotton into balls, place these on top of each other, in a small, tubular, screw-top glass bottle, bake from two to four hours at a temperature of 140° F., and open the bottle only when required for use.

* These curettes are made of stout steel wire drawn to a point, the point flattened into a disc, and the disc bored in the centre and filed at the edges to make a ring; the larger end of the wire is bent at an angle of forty-five degrees and made into a ring-shaped handle. They are simple in construction, easily made, and inexpensive.

The common seats of limited necrosis in the epitympanum are the head of the malleus, the body of the incus, and the outer epitympanic wall. The thorough cleansing of the epitympanum, which is necessary to the satisfactory treatment of all cases of suppurative epitympanic disease, and as an adjuvant to surgical interference, is best effected by means of the middle-ear syringe and the use of hydrogen dioxide; but as this remedy is, when used undiluted, distinctly irritating to the skin in some individuals, it is well previously to smear the canal walls lightly with vaseline. Limited curetting may be effectually done upon any portion of the tympanic wall or of the ossicles, but should be carefully restricted to the diseased area.

In the event of a considerable necrosis of the two larger ossicles, or when their presence presents an obstructive barrier to drainage from the epitympanum or to access to other diseased parts, their removal is indicated.

This operation should be done under general anæsthesia, not only because it is painful and may need to be considerably prolonged, but because a thorough examination and possibly curetting of the tympanic walls is a part of its purpose.

The instruments necessary, in addition to specula, blunt probes, cotton sticks, paracentesis needles, and a slender curved bistoury, are a spatula-shaped knife, for division of adhesions in the epitympanum, a wire snare or stout forceps for extraction of the malleus, an incus hook, or a blunt angular curette for removal of the incus, and a small blunt hook for use about the stapes; in addition, there should be a saturated solution of boric acid in alcohol and a solution of extract of suprarenal capsule, the former for dipping the instruments and the latter for controlling the sometimes annoying bleeding which obscures the field and prolongs the operation.

If the perforation is in the membrane of Shrapnell, the drumhead being intact, or if the perforation of the drumhead is small, the entire removal of that membrane accompanying the evulsion of the malleus may seem desirable, or the posterior portion of the drumhead may be retained to be carried inward and attached to the head of the stapes.

In this as in most other middle-ear operations under general anæsthesia, two assistants can be employed with advantage: one to etherize and to control the position of the head of the patient, the other to twist cotton sticks, cleanse and dry the instruments, and hand them to the surgeon when he wishes to keep his operative field continuously in view. Before using, and after each successive cleansing and drying, the blades of the instruments should be dipped in the alcoholic solution of boric acid, the speedy evaporation of the alcohol leaving the steel covered with a thin film of boric acid which dulls the metallic lustre and makes the instrument more plainly visible.

Partial or complete peripheral excision of the drumhead should be done with the parencentesis needle or curved bistoury, the membrane being, in addition, stripped from the handle of the malleus for the sake of removing an obstruction to both sight and manipulation and of making the malleus and the parts beyond it more accessible.

If the incus is in place and it is desired to remove it also, either subsequently to or simultaneously with the removal of the malleus, the next step would be the division of the incudo-stapedial articulation by means of the angular knife carried into the joint, from below upward, and cutting from behind forward against the pull of the stapedius muscle. The release of the incus from its attachment to the stapes allows the descending process to swing outward and downward into view and close to the long process of the malleus. If this movement fails to take place, it may be aided by means of the blunt hook, or, if desirable, the incus may be at once extracted. By passing the angular knife behind the tip of the long process of the malleus and carrying it upward in contact with the bone, the tensor-tympani tendon is felt and divided, the complete cutting of the tendon being usually made apparent by the increased mobility of the malleus. The division of the anterior and posterior ligaments of the short process, which steps follow next, leaves the malleus freed from its major attachments and makes it possible to determine how firmly it is held in place by other means, and, if it is resistant to a light pull with the forceps, the curved spatula knife should be passed upward into Prussak's space and swept backward and forward to divide the adhesions and thickened mucous membrane reduplications which fasten the heads of the larger ossicles to the outer epitympanic wall. To extract the hammer and anvil simultaneously, or to remove them individually, the loop of the wire snare should be drawn tightly about their descending processes as high up as possible, the movement of withdrawal being downward and slightly from side to side. If completely freed from attachment, they come away easily, and that these bonds should be thoroughly cut, especially above the short process of the malleus, is important because it is an evil experience, in removing that bone, to peel away the soft tissues from the superior wall of the inner end of the auditory canal. Throughout the operation, the extract of suprarenal capsule can be used with good effect, and after removal of the ossicles, the tympanum, and especially the epitympanum, should be swabbed with the alcoholic solution of boric acid and then dry-scrubbed by means of a cotton-tipped probe. The subsequent examination should include careful tactile survey of the tympanic and epitympanic walls and a determination of the condition of the stapes, necrotic spots should be curetted, adhesions in the fenestral niche divided, and if the stapes is otherwise free and can be utilized for sound transmission either by membranous attachment or the use of an artificial drumhead, the tendon of the stapedius muscle should be divided.

At the conclusion of the operation, the middle ear should be wiped dry, the canal washed with sterile water by means of a cotton-tipped probe, similarly scrubbed with alcohol, and then stopped with sterile cotton, this dressing to be renewed within forty-eight hours under aseptic precautions.

New cicatricial protective tissue forms rapidly from the cut edges of the drumhead in many of these cases, and especially, apparently, in those in which the middle ear has been rendered aseptic by operation and allowed to fill in with blood clot.

The obstructive changes which occur in the middle ear in non-suppurative diseases are so varied in location and extent as to make the question of the success of operation for relief of impairment of hearing a dubious one without better preliminary knowledge of the point in the sound-transmitting apparatus to be attacked and the extent of interference justifiable. Under these conditions of dubiety, it is very natural that recourse should be had to the somewhat desperate and frequently ineffectual major operation of removing the drumhead and two larger ossicles, but leaving the stapes, which was either or thus became the key to the unfortunate situation, untouched.*

This operation follows the same lines as the similar operation in suppurative cases; it is, however, comparatively bloodless, and the field remains clear; it demands, like the exploratory tympanotomy, the most stringent aseptic precautions.

Forcible mobilization of the ossicles by other than applications external to the middle ear may be effected by making a triangular cut in the posterior superior segment of the drumhead opposite the descending process of the incus and the stapes and the introduction of a small, blunt hook. The objections to this method of operating are the smallness of the field exposed and the consequent

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* Kessel's operation of removal of the drumhead, malleus, and incus, while exact as a surgical procedure, simple, easily done, and attended with but little risk, is unjustifiable unless warranted by a previous knowledge of what it is likely to effect in the individual case. In several cases of this kind which have come to my knowledge after the operation and when cicatricial healing had taken place, tenotomy of the stapedius muscle alone, or with the use of an artificial drumhead, has given the sought-for improvement in hearing.

difficulty in manipulation; the location of the opening, in the centre of an important segment of the membrana vibrans, is of less importance, as it is well known that fresh incisions in the drumhead heal so readily that attempts to maintain a permanent opening by excising large portions, by the use of escharotics, and by introduction of eyelets have mainly failed of their purpose.

To permit free access to the middle ear in the line of the ossicular chain, to avail of the intelligent participation of the patient, and, if any operation more serious than an attempt at mobilization is found to be unjustifiable, to permit the immediate closure of the opening in the drumhead and the restoration of the parts to their former condition, the operation called exploratory tympanotomy was devised. This operation consists in an incision along and close to the posterior and superior periphery of the drumhead, beginning at a point opposite the round window, or a little higher, and ending close to the handle of the malleus below the short process; the dendritic fibrous tissue in the flaps thus formed tends to pull it downward and outward, thus exposing, without the need of manipulation, the descending process of the incus and the stapes, and permitting free, tactile access to the tensor-tympanic tendon and the tendon of the stapedius. The operation is done without general anæsthesia, thus making hearing tests during its progress possible, and is comparatively painless if the cut is made close to the periphery and if contact with the skin of the canal is avoided; in especially sensitive patients the incision may be suspended in its lower third and a sterile cocaine solution applied. Hemorrhage, even in the upper part of the cut, is usually inconsiderable, and can be easily controlled by sopping with a dry, cotton-tipped probe.

In a series of experiments on the progressive growth of the dermoid coat of the membrana tympani, it was found that the movement outward from the centre of the membrane at the tip of the malleus toward the superior and posterior periphery was slowest in the inferior third of the posterior segment, more rapid in the middle third, and most rapid in the upper third, and that the rate of movement, as shown by small pieces of paper pasted upon the membrane, bore a proportionate relation to the corresponding degree of vascularity of the three sections mentioned. Tactile examinations show that the sensitiveness of the sections of the posterior segment of the membrana tympani has the same relative correspondence, and therefore that an incision, begun opposite the round window, causes increasing pain, as it is extended upward and forward along the periphery.

A part of this progressive increase in pain can, of course, be accounted for psychologically; but it is evident that the edges of a small and comparatively painless cut can, by affording access to the mucous membrane forming the inner coat of the membrana tympani, be availed of for purposes of anæsthetization by cocaine, and that the cut can be successfully continued under the same influence and with comparatively little discomfort.

Tactile investigations as to the comparative sensitiveness of the different portions of the tympanic cavity also show its lining membrane and intrinsic structures, with exception of the superior and posterior portions—fornix tympani and aditus ad antrum mastoideum,—to be comparatively insensitive, especially in the line of the sound-transmitting apparatus of the middle ear.

Operations within the middle ear, therefore, except such as include interference with the membrana tympani and invasion of the upper portion of the tympanic cavity, may, in the great majority of non-suppurative cases, with proper care, be conducted not only without general, but also without local, anæsthesia; and in the cases, therefore, of chronic non-suppurative disease of the middle ear with intact membrana tympani, for which this operation of exploratory tympanotomy is proposed, when the sensitive membrana tympani has once been passed, there is opened to the observer an aseptic and comparatively insensitive cavity.

The successive stages of the exploratory tympanotomy are, first, the crescentic incision beginning in the posterior segment and carried upward and forward through the thin and comparatively insensitive portion of the drumhead between the annulus cartilagineus and the periphery, and then downward along the posterior border of the handle of the malleus. This cut may sometimes be completed without withdrawing the knife, but usually it is necessary to suspend it when the upper portion of the drumhead is reached, either for the purpose of making an application of cocaine or to allow the patient a moment of rest. Almost immediately upon the completion of the incision the flap thus formed curves downward and outward, leaving the descending process of the incus and sometimes the posterior crus of the stapes, the stapedius tendon, and the corresponding portion of the inner tympanic wall plainly in view. Bleeding from the cut edges is taken up by the cotton stick and the wound allowed to glaze. During this period of waiting the hearing tests are made and recorded.

Second, a small, blunt hook, previously dipped in the alcoholic boric-acid solution, is passed through the opening, care being taken to avoid touching the cut edges and inner surface of the flap, and the mobility of the malleus is tested by a series of gentle pulls, the same process being repeated by passing the hook behind the descending process of the incus and under the head of the stapes, the various degrees of fixation or mobility being determined by this means.

Third, from a piece of thin, foreign post paper, highly sized, there is cut, by means of curved scissors, a disc large enough to cover the flap formed in the drumhead and to extend upward over the periphery of the drumhead on to the inner end of the canal. This disc, dipped in a weak, corrosive solution to moisten its sizing, is then taken upon the end of a wet, cotton-tipped probe, and its lower half brought into contact with the outer surface of the flap in the drumhead and held in position for a few seconds until it adheres, when the paper, carrying the flap with it into position, may be similarly attached to the skin above the incision, thus bringing the edges of the crescentic cut in apposition and holding them firmly in place. The patient should be directed not to practise inflation, the ear should be lightly stopped with sterile cotton, and this dressing allowed to remain in place until the healing of the drumhead, which usually occurs within three days, has taken place.

In the second stage of this operation there may be included almost any form of interference in the line of the sound-transmitting apparatus of the middle ear, other than evulsion of the two larger ossicles. It is possible to disarticulate the incus and stapes, cut the tendon of the stapedius, and extract that bone and the incus also through such an opening as that described.

The operation of stapedectomy, while very simple in itself, is open to question because of the varied consequences which may follow invasion of the cavity of the internal ear, and because of its doubtful value for the purpose for which it is usually demanded—amelioration of an extreme degree of deafness.

When the extreme deafness is accompanied by disturbing or incapacitating tinnitus and vertigo, the removal of the stapes may be considered a justifiable expedient, and has occasionally proved of benefit. It should be borne in mind, however, that the fixation which causes these extreme symptoms is, not infrequently, only secondary to a hyperostotic process of the labyrinthine capsule which removal of the stapes cannot relieve, that, under these circumstances of fixation, the crura not unusually break in the attempt at extraction, and that there remains then only the alternative of drilling or of breaking up the base plate.

In 21 consecutive cases of attempted removal of the stapes in chronic, non-suppurative disease of the middle ear, the stapes was removed entire in 9 cases only; there was fracture of both arms of the stapes in 10 cases, and in 2 cases the bone was found to be so absolutely immovable as to make it impossible to rotate the head of the ossicle by traction upon the blunt hook inserted between the crura. In 6 of the cases, which had not been dizzy before, vertigo, more or less severe, followed the operation, persisting for more than a month in 3 of them, in 1 for nearly a year, and in but 3 out of the 21 cases was there improvement in hearing, except temporarily.*

As an example of the feasibility of operation upon the middle ear through the exploratory tympanotomy opening, the following case, that of a woman fifty-five years of age, in whom the operation included the removal not only of the stapes, but also of the incus, may be cited. At the time of operation, there was marked decrease in hearing in both ears in consequence of chronic, non-suppurative disease of long standing, and in the right ear neither Politzer's acoumeter, nor the tuning-fork, nor the upper portion of the scale of the Galton's whistle was heard. Subsequently to the injection of a two-per-cent. solution of cocaine through the Eustachian catheter, the crescentic, peripheral cut in the right drumhead was made with but one application of cocaine solution to the edges of the cut and with but little discomfort to the patient. Tests of hearing at the end of the first stage of the operation showed no improvement either by aerial or by bone conduction, and served to confirm the diagnosis of fixation of the stapes in consequence of the long-continued thickening process in the middle ear. Careful tactile examination of the accessible portions of the inner tympanic wall, especially in the neighborhood of the fenestral niche, by means of a probe, showed lack of sensitiveness to touch, with the exception, perhaps, of a slight pricking sensation; if, however, the probe came accidentally or intentionally into contact with the cut edges of the drumhead, especially upon the superior posterior margin, there was a sense of discomfort, which amounted to pain as the effect of the cocaine passed off, which it apparently did before the more important part of the operation was concluded; care was therefore taken in subsequent manipulation to avoid touching the edges of the opening. Under these conditions the operation, including tenotomy of the stapedius muscle, disarticulation and removal of the stapes, was continued and completed without pain. The division of the tendon caused to the patient the sensation of a dull thud, and in dividing the articulation between the incus and stapes the grating sound made by the knife was similarly heard. The ankylosis at this point was very firm, and disarticulation was effected with such difficulty that at its completion the incus dropped not only outward, but also slightly downward, in such a manner as to show that it was separated from the malleus also; its removal, therefore, seemed advisable, and this was easily done by means of the blunt hook and forceps, the only pain caused being incident to the passage of the body of the incus through the opening in the drumhead. The stapes was now plainly in view, and as no improvement in hearing had thus far been effected, this bone also was extracted, by means of a blunt hook passed between the crura from above, and came away with a sensation, to the patient, of a loud report, but without causing either pain or vertigo; the pulse, which had been 80, rose to 100 and became weaker, but returned to its former rate and volume within two minutes. Subsequently to the operation there was no other discomfort than that naturally incident to having the head held for a long time in a constrained position, and in this respect, as well as in the conditions of the operation itself, the result was a satisfactory one, although the hearing was not materially improved.

In a man twenty-nine years of age the hearing in both ears had become impaired, and in the left ear gravely affected, as the result of a chronic non-suppurative disease of the middle ear. The Politzer acoumeter was heard only when held so close to the ear that the hammer was on a line with the posterior border of the concha; the tuning-fork (512 v. s.) was heard aerially $\frac{25}{65}$, and by bone conduction $\frac{35}{65}$; Politzer's forks, Nos. 1 and 2, were not heard aerially, nor was a Galton's whistle, ranging from 6,000 v. s. to 12,000 v. s.

After the first stage the operation was painless, except when the shaft of the instrument touched the cut edges of the drumhead, but it was accompanied by the auditory sensations incident to tenotomy and disarticulation.

Efforts at mobilization showed the stapes to be firmly fixed, and in an attempt at circumcision by means of a fine paracentesis needle, the knife met with bony resistance on the superior and posterior borders of the niche, and gentle traction, made with a blunt hook, resulted in the coming away of the head and both crura of the stapes broken off close to the foot plate. There was no sense of suction on this extraction, no vertigo, no change in pulse, and no special sensations to the patient, except a snapping noise which was presumably heard at the moment of fracture. Investigation of the fenestral niche by means of a probe showed the base plate to be apparently fixed by bony union, especially to the posterior and superior niche walls; subsequent examination of the crura showed them to be distinctly atrophied, as is the case in long-continued ankylosis of the base plate of the stapes. The whole operation, including the tests of hearing made during its progress, lasted but twelve minutes and was without pain to the patient, who was, however, it should be said, a well man of an equable temperament. Five days after the operation, during which interval there had been neither pain nor other discomfort, the hearing test gave the same result for Politzer's acoumeter and for duration of the tuning-fork aerially; but the hearing was improved in the following respects: Galton's whistle, previously not heard at all, was now heard throughout its whole register; the tuning-forks, Nos. 1 and 2, were heard plainly, as was also the voice in a low tone, close to the ear; a loud voice, however, even if one or more feet distant, was heard only confusedly.

Clarence John Blake.

EAR DISEASES: SYPHILITIC AFFECTIONS.

—I. ACQUIRED SYPHILIS — AURICLE. — *Primary syphilitic chancres* have been but very seldom seen on the auricle and the adjacent parts. Desprès[1] found among twelve hundred syphilitic patients one with a chancre (soft) on the auricle. Pellizzari[2] reports having seen a primary sore on the lobule, and thinks that it was caused by the use of a towel which the son of this patient had previously used in cleaning a sore on his penis. Hermet[3] saw a chancre on the lobule of a woman's ear, which resulted from a kiss by her infected husband. The same author[4] saw also, in the clinic of Dr. Fournier in Paris, a phagedenic hard chancre on the lobe and the posterior part of the lower third of the auricle, caused by the bite from an infected individual. A similar case, due to a bite, has been observed also by Hutchinson.[5] Hulot[6] saw a chancre on the base of the tragus, the origin of which was problematical. Zucker[7] has described at length the history of a case of chancre on the outer surface of the tragus. A chancre on the mastoid process in a man, due to the kiss of a prostitute, has been observed by Mracek,[8] and another in the same place in a child, caused by infection from the nurse, has been described by Hulot.[6] Finally, Lincke,[9] speaking of otitis syphilitica externa, says that it attacks sometimes the auricle, at other times the external canal, or it may attack both parts simultaneously, and that it manifests itself usually in the form of a chancre.

As far as can be seen from the description of the cases here cited, the chancres presented the usual appearance; the lymphatic glands in the vicinity were enlarged and indurated. In Zucker's case the tragus was of a livid red color, of twice the normal thickness, and on its anterior surface was a pigmented radiating cicatrix. The entire parotid region was involved in the process; it was greatly swollen, felt as hard as a board, but was not at all painful. There was no secretion from the external canal, and the hearing was but slightly diminished in acuteness. In this case the diagnosis of primary syphilitic infection was facilitated by the recent appearance, on the surface of each hand, of three or four small, round, slightly scaly efflorescences. The genitals were intact, and the inguinal glands were not swollen. A course of inunctions produced a perfect and rapid cure.

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* In a case of destruction of the drumhead and loss of the malleus and incus incident to suppurative disease in childhood, there had been no cicatrization. The mucous membrane of the tympanum was clear, dry, and transparent; the stapes was plainly visible in the niche, but without attachment of the stapedius muscle. For hearing purposes this ear (the right) was practically useless. Removal of the stapes, which came away easily with a slight sense of suction, was followed by an outflow of fluid and immediate increase of hearing (the voice being heard twenty feet) and a severe vertigo; the hearing and vertigo lasted ten days, and then both disappeared.

A primary sore on the auricle may be mistaken for cancer, from which it differs, however, in that it presents a clean surface and secretes but little. The nearest lymphatic glands usually enlarge with the development of induration in the primary sore.

Secondary and Tertiary Forms.—Manifestations of constitutional syphilis are not very rarely observed in the auricle. Squamous, pustular, and papular eruptions, usually in connection with the same affection on the integument of adjacent parts, but sometimes limited to the auricle and external canal, have been seen by many writers. According to Gruber,[10] papular eruptions are most frequently seated at the point of insertion of the auricle, while exanthematous eruptions appear mostly on the other parts of the auricle. Broad condylomata have been often seen by Desprès on the lobule, and usually in the hole for the earring. Wilde,[11] as far as I know, is the only author who maintains that syphilitic ulceration is by no means uncommon, and that rupia is frequently seated on the external ear.

Tubercular syphilides* and gummata of the auricle have been observed by Zeissl,[13] Burnett,[14] Buck,[15] Field,[16] Hessler,[17] Pelletan,[17] Sexton,[18] Pierce,[19] Ravogli,[20] Woakes,[21] Barklay,[22] Bumstead and Taylor,[23] McBride,[24] and Packard.[65] In all of the cases reported, the affections appeared in the so-called tertiary stage of syphilis. In almost all only one ear was affected, and in the majority of the cases no other symptom of syphilis was present at the time the patient came under observation. The seat of the tubercle or gumma was in the anterior part of the auricle in all the cases, except Burnett's, in which it occupied the posterior surface. A case with symmetrical patches of lupus erythematosus in the concha of each ear, probably syphilitic, was seen by Hutchinson (*loc. cit.*, p. 348). According to Zeissl, the auricle may be the seat of both the dry (non-ulcerating) and the ulcerating forms of gummata, and the latter frequently shows a tendency to the lupoid character in this situation (Fournier). In Burnett's case, which is about the only one recorded in which the disease was seen in its earliest stages, there first appeared a circumscribed infiltrated lump on the posterior surface of the auricle, and this gradually extended until it had diffused itself throughout the tissue of the pinna. It was slightly elevated above the general surface of the auricle, of a deep reddish color, painless, and was not attended with itching; it was inclined to run a slow course. In the space of a month or six weeks the infiltration had diffused itself throughout the greater part of the auricle, and somewhat over the mastoid portion. The thickening and deformity of the auricle had become considerable, the groove behind the auricle was obliterated, and the appendages assumed a firm, thick feeling. This condition lasted for some weeks, then softening and ulceration ensued, the latter beginning in some natural groove or depression. The ulcer thus formed by the breaking down of the gumma may assume any shape, and if not properly treated soon increases in size and depth. The floor of the ulcer is usually ragged and covered with dirty grayish matter which cannot be readily removed. The discharge from the ulcer is often excessively offensive. In several of the reported cases, necrosis of parts of the auricular cartilage and exfoliation of the sequestra occurred, and in Field's case two-thirds of the auricle was destroyed. As a rule, comparatively little deformity seems to result from this affection, sometimes even when the infiltration is extensive and the ulcer large and deep; very often an indelible, depressed white scar is in after-years the only evidence remaining of the gumma. In Barklay's case, in which the cartilage of the concha, tragus, and canal was exfoliated, the general outline of the ear remained normal. The first abnormality to strike the attention was the peculiar deformity of the concha, the upper and lower limits of which were preserved, while the tragus and meatus were absent. The beginning of the helix above was at an oval pit in the concha, and the intertragal notch below was a circular pit. There was a shining, bulging, yellowish spot—resembling somewhat a sebaceous cyst—right over the site of the normal meatus, upon a strong band of cicatricial tissue, extending downward and backward from a spot above and in front of the site of the normal tragus, which band completely closed the meatus. Except a slight tightening of the skin, a seeming loss of subcutaneous tissue on the anterior side, and a slight drawing outward and forward of the auricle, it was otherwise apparently normal. Above and anterior to the site of the normal tragus, and near that of the temporo-maxillary articulation, was a stellate cicatrix.

Packard's case[65] was that of a negro twenty-five years of age. A painful swelling, fluctuating on pressure, developed in the upper portion of the auricle twelve years after the primary sore. There was no history of injury. Under treatment the auricle attained its normal condition, except for the presence of some hardening and thickening of the cartilage, in a month.

The *diagnosis* of the diseases under consideration, as well as of those which I shall treat farther on, must rest largely on the previous history of the case. If syphilitic infection is denied, and necrosis of, or gummata on, the bones are absent, careful search should be made for scars and marks left by secondary affection of the skin and mucous membranes. An ulcerated tubercle may possibly be confounded with lupus vulgaris and scrofulous ulcer. In both of the last-named affections there is, however, very frequently considerable redness and œdema of the skin around the ulcer, while the syphilitic ulcer is, in most instances, sharply bounded by healthy-looking skin. Lupus vulgaris begins, moreover, usually before puberty; its course is much more chronic, and there is but little discharge from the ulcer.

From an ulcerating epithelioma* the syphilitic ulcer can generally be distinguished by the absence of enlarged glands in the neighborhood, and by the more offensive odor of the discharge.

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* The tubercular syphilide is a solid rounded nodule of the skin and subcutaneous cellular tissue, and is coppery or purple-brown in color; commonly several tubercles are collected in a group. The tubercle is liable to ulcerate, and its course is slow. Sometimes creeping ulceration attacks a tubercle. When this takes place, little tubercles develop at the margin of the first deposit and merge into each other. The original tubercle soon ulcerates; a scab is formed, under which the ulcer creeps, healing where the tubercle first began to melt away, and spreading by the destruction of the tubercles at the margin of the ulcer. The course of the affection is indefinite, unless controlled by treatment. Ulcerated tubercles always leave indelible white scars. Gummy tumors form solid nodules beneath the skin. Presently the skin becomes absorbed over the tumor, and, bluish-red in color, breaks down in slow ulceration. Sometimes the mass is absorbed before ulceration is reached (Hill and Cooper[12]).

* *Differential Diagnosis between Ulcer, Tubercle, and Cancer.*—Hutchinson (*loc. cit.*, p. 511), speaking of the differential diagnosis between cancer and syphilis, says: "I am most anxious to insist on its extreme difficulty. The surgeon who trusts to rules, or who ventures to rely with confidence on his own powers of observation as regards minute differences of appearance between cancerous and syphilitic ulcers, will often make serious mistakes. Cancerous processes may be simulated by syphilis in the closest possible manner. As a general rule, it may be said that we distinguish between a cancerous ulcer and one that is syphilitic by observing that in the former a process of growth precedes that of ulceration, whereas in syphilis it is at best only one of chronic inflammation. Without doubt this is a most important distinction. In syphilis the edges of an ulcer may be greatly indurated and its base may be firm, but there are seldom any sprouting masses on the surface, or any well-defined margins to the induration, such as we encounter in cancer. Exceptions, however, occur even to this statement, and now and then even a syphilitic sore may be covered with bossy masses of firm granulation structure which closely resemble epithelioma. I possess more than one drawing in which the ordinary features of rodent ulcer, its clean surface, and its sinuous, rolled edge of induration, were so exactly imitated by tertiary syphilitic sores that we had to appeal to treatment for diagnosis. I have not attached much importance, for diagnostic purposes, between syphilis and cancer, on the presence or absence of implication of lymphatic glands. Nothing can be more illusory than to teach that enlargement of the lymphatic glands is one of the *features* by which cancer can be distinguished from other local disease. There is no doubt, however, that in any case which comes under observation late, and with enlargement of the

The *treatment* of these affections does not differ from that of tertiary manifestations in other parts of the body. Iodide of potassium, alone or combined with mercury, will cure these cases.

Local treatment alone was of no avail in any one of the cases reported.

EXTERNAL AUDITORY CANAL.—This part of the ear is not very rarely the seat of *Broad Condylomata* (*Mucous Warts*) and of ulcers in persons suffering from constitutional syphilis. The occurrence of the condylomata of the external canal is mentioned by Moos and by Troeltsch; but for the first full description of this affection and its treatment we are indebted to Stöhr,[25] who had the opportunity of seeing fourteen cases of this disease in about three years. Wilde's (*loc. cit.*, 222) case, published nearly twenty years before Stöhr's paper appeared, may, as Knapp suggests, have been also one of syphilitic origin; but Wilde, who throughout his book shows that he was familiar with the manifestations of syphilis in the ear, says expressly that the patient was otherwise healthy, and attributed her affection to cold.

Since Stöhr's publication broad condylomata have been observed and described by Buck,[15] Knapp,[26] Christinneck,[27] Noquet,[28] Zucker,[7] Purjesz,[29] Felici,[30] Trautmann,[31] Kochner.[32] Després[1] found among 1,200 syphilitic patients (980 of whom had condylomata in various places), 5 cases of condylomata of the external canal; while Ravogli was unable to find a single case of condylomata of the external canal in 144 syphilitic individuals (77 of these had condylomata in other parts of the body) whose ears he had examined. Buck saw but 2 cases in 3,976 ear patients; Knapp met with only 1 case in from 9,000 to 10,000 ear cases; and the writer of this has seen but 2 cases out of about sixteen thousand ear patients. Analyzed with regard to the sex, the published cases show a preponderance among the females. In most cases but one ear was affected. As a rule, condylomata of the external canal appear early in constitutional syphilis, while other skin eruptions, ulcerated papulæ on the fauces, and glandular swellings are present. In most cases purulent inflammation of the middle ear, sometimes of long standing, precedes the development of the growth. Condylomata begin as broad, slightly reddish papulæ, the surface of which at first is dry, but soon becomes moist. The papulæ gradually grow in size, and when situated close to each other they coalesce into large patches. These are often subdivided by rhagades. In most cases the upper surface of the excrescence, which is at first smooth and somewhat convex, becomes ulcerated and secretes a sero-purulent fluid, which often causes inflammation and ulceration of the adjacent parts free from these growths. If ulceration does not occur, the epidermis covering the excrescence becomes thickened, whitish, and granular. These growths often occur in great numbers in all parts of the canal, and may even be seated on the drum membrane. Sometimes they not only fill the canal, but also protrude out of the external meatus. The excrescences are at first painless, but after ulceration has occurred they often cause severe pain, which is increased by movement of the jaw. More or less impairment of hearing and tinnitus usually result from the obstruction of the canal, and occasionally a purulent inflammation of the middle ear is developed subsequent to the appearance of the warts. In one of Buck's cases (*American Journal of Otology*, i., p. 26), a man, aged twenty-eight, who had had otorrhœa for seven months before, but whose hearing was not impaired, the orifice of the meatus was found almost completely obliterated by the presence of an elevated patch of what seemed at first granulating tissue. The dividing line between this patch, which completely encircled the orifice and the healthy skin of the auricle, was sharply drawn, the edges of the elevated portion being quite abrupt. In Knapp's case, the condylomata developed a few months after infection, and when the patient came under his observation, six months after he had contracted syphilis, he found the ear canals filled, and the external orifice of the meatus and the adjacent parts of the concha occupied, all around, by reddish, wart-like excrescences resembling the syphilitic condylomatous growths so often seen at the anus. Some of these were ulcerated at their apices and discharged a thin, watery fluid. A papular syphilide covered the whole body, and was very marked on the forehead. In the soft palate there were ulcers with unclean bottom and raised concave edges. The glands of the neck were swollen, and the patient was very pale and weak. During the first weeks of treatment, however, there was an aggravation of the affection of the pharynx. She suffered intense pain in the ears, and was relieved when profuse purulent discharge from the ear set in. The walls of the ear canals were so much swollen that no speculum could be introduced; yet the characteristic whistling sound on inflation showed that both drumheads were broken. The patient recovered fully under antisyphilitic treatment.

The diagnosis of broad condylomata of the external canal can usually be made without difficulty, as manifestations of secondary syphilis are almost always present in other parts of the body at the same time.

The prognosis is favorable. Under constitutional antisyphilitic treatment and the local applications to be mentioned, the excrescences usually shrink rapidly, and eventually disappear entirely. Depressed cicatrices, destitute of hair, sometimes remain, but permanent contraction of the canal very rarely follows this affection.

Constitutional treatment alone will in most cases cause the condylomata to disappear. But if they occlude the canal and cause retention of the discharge from the tympanic cavity, they may be abscised or carefully cauterized with nitrate of silver in substance. Thorough cleansing of the canal with warm salt water and inflation of the middle ear should also be practised if suppuration of the middle ear is present. In some cases benefit was apparently derived from dusting iodoform or calomel on the excrescence, or washing the same with a one-per-cent. solution of nitrate of silver.

Syphilitic ulcers of the external canal seem to have been observed by some of the older writers, as Bell, in his work on Lues, speaks of deafness produced by a "scruffy" eruption, and sometimes ulceration of the external auditory passage, occurring as a consequence of that disease. Referring to this Wilde says: "But his description is not sufficiently accurate to be depended upon, and has not been confirmed by subsequent observers. No doubt, cutaneous syphilitic disease will extend by ordinary continuity of surface into the meatus, but as a special form I am unacquainted with it" (*loc. cit.*, p. 198). Since Wilde's time such ulcers have, however, been frequently observed, and have been studied especially by Schwartze.[33] According to this author they are usually annular in form and covered by a dirty, grayish-white exudation. Their edges are usually greatly swollen, and may thus cause considerable diminution of the calibre of the canal. They were seated in the outer part of the canal up to the point of union of the cartilaginous and osseous portions, and were found in one or both ears. He saw these ulcers in ears with normal membranes and healthy middle ears, but in most cases they were associated with chronic purulent inflammation of the middle ear and perforation of the drum membrane. The glands in the vicinity of the ear were always much swollen in these cases, and other manifestations of constitutional disease were never wanting. The treatment recommended by Schwartze consists in

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glands already existing, we may take this part as important evidence in support of the diagnosis of cancer. Neither in secondary nor tertiary syphilitic lesion is it at all common for there to be any implication of lymphatics." "In very obscure cases the aid of the microscope should be invoked, and if this should fail to give positive evidence one way or the other, the patient should be given the benefit of the doubt and be put under antisyphilitic treatment. In cases in which it is desired to use treatment as a means of diagnosis, the best plan will usually be to rub in mercury pretty freely, and to give iodide of potassium by the mouth at the same time. Under this plan any growth or ulcer of syphilitic origin ought within a week or ten days to change its features in an unmistakable manner."

energetic cauterization with nitrate of silver in substance, which, though painful, may be relied upon to heal the ulcer. Hinton[34] has also seen secondary syphilitic ulceration of the meatus, mostly in the form of a narrow, unhealthy ulcer at the orifice, attended with an ichorous discharge and general inflammation and swelling of the passage. The appearance and history sufficiently mark its character, and in the cases Hinton[34] saw, iodide of potassium and black wash brought about a cure. A case of this kind has been described by Buck.[15] The patient had acute purulent inflammation of the middle ear, with perforation of the drum membrane. The ulcer occupied the lower wall of the outer half of the canal and extended outward upon the auricle. The limits of the ulcer were well defined. The chancre had appeared one year before, and there was also syphilitic pharyngitis.

Politzer has observed two cases of this description. In one, with chronic purulent inflammation of the middle ear, the ulcer occupied the lower lateral wall of the cartilaginous portion. Syphilitic ulcers of the pharynx were present at the same time. In the other, the ulcer extended along the entire length of the cartilaginous portion, and a second ulcer with everted edges occupied the concha.

In a case reported by Jacobson,[35] the patient had been afflicted, up to within a few months before he came under observation, with chronic suppuration of the middle ear. He was suffering intense pain in the head, and had other symptoms of cerebral irritation. He had contracted syphilis six months before, and had ulcers on the palatine arches at the time. The ulcer, which was seated at the entrance of the right external canal, was of the form of a ring, its floor was covered with an adherent, dirty, whitish-gray exudation, and its margin was much swollen. It was very sensitive to the slightest touch, and the tragus and mastoid process were tender on pressure.

Diagnosis.—Non-specific ulcers of the external canal are very rarely seen, except in children with neglected purulent inflammation of the midlde ear, and in eczema of the canal in adults, and the presence of an ulcer should therefore always arouse suspicion as to the existence of constitutional syphilis. It seems hardly possible that the opening of a furuncle can be mistaken for ulcer by any one at all familiar with ear affections. In cases of syphilitic ulcer the glands near the ear are always swollen, and other signs of syphilis are never absent.

Diffuse inflammation of the external canal due to syphilis is said by Ladreit de Lacharrière to be of frequent occurrence in the secondary stage. According to this author both canals are usually attacked simultaneously; there is only moderate swelling; the skin is red and cracked, and the discharge is very offensive. But McBride[32] appears to be the only other author who has seen such a case, and in his there was no disagreeable odor. If we exclude the cases in which papulæ or condylomata are present, the secretion from which causes inflammation of the lining of the parts of the external canal free from them, instances of diffuse inflammation of this part are doubtless very rare in syphilitic persons. The writer of this article has seen but a single case of this kind, and this occurred many years after infection, and was associated with non-purulent inflammation of the middle ear, and caries of the superior maxillary and palate bones of the same side. In this case the walls of the osseous part of the canal were very red and somewhat swollen. The pain was very great, and not much relieved by repeated deep and long incisions, which at no time liberated pus. The walls were at no time covered by exudation, and there was but little secretion from them. The drum membrane was but little inflamed, and although it was repeatedly freely incised in the hope of giving exit to supposed pent-up secretion in the tympanic cavity, none escaped. The Eustachian tube was almost impermeable. After much and long-continued suffering the pain subsided eventually while the patient was taking iodide of potassium; complete deafness remained.

The characteristic symptom of syphilitic inflammation of the external canal is said to be very severe pain, even when the swelling is not very great, which is not relieved by the usual remedies, but yields at once to constitutional treatment (Schwabach).

Exostoses of the external canal may, according to Gruber, be caused by syphilis; but nearly all other writers deny that syphilis has anything whatever to do with the production of these growths.

THE DRUM MEMBRANE.—This part of the ear appears to be but rarely the seat of syphilitic infiltration and growths. Lang[36] observed a case in which there was a large, pale, glistening papule at the place of the short process of the hammer on a drum membrane; the membrane itself was very red in its anterior upper quadrant, and slightly opaque throughout. The patient was a woman, with early symptoms of constitutional syphilis.

Condylomata, as we have seen, have been found here in a few cases, in which these growths existed also on the walls of the canal.

Baratoux[37] has recorded the case of a woman in whom he found five small gummata on the cheek, in front of the ear; a sixth on the mastoid process; three in the concha and outer part of the external canal; a small egg-shaped, prominent, faintly opalescent, gummatous tumor on the lower posterior part of the drum membrane; and a small, round ulcer, covered with a yellowish-white, adherent substance, in front of the handle of the malleus.

The gumma on the drum membrane became ulcerated at its summit in a few days, while the ulcer was cicatrizing.

MIDDLE EAR.—The diseases of the middle ear observed in individuals afflicted with constitutional syphilis do not differ essentially, in their objective and subjective symptoms, from the same diseases occurring in non-syphilitic subjects. Most writers are agreed, however, that the syphilitic forms are characterized by a marked tendency to implication of the labyrinth, or, to speak more precisely, by the appearance of symptoms commonly regarded as indicative of disease of the auditory nerve, at an unusually early period. The middle-ear disease may present itself in the form of an acute catarrhal inflammation, a chronic catarrhal inflammation, a purulent inflammation, or as a neuralgia of the tympanic cavity.

Acute Catarrhal Inflammation.—This disease is usually, but by no means always, associated with syphilitic disease of the naso-pharyngeal cavity. Frequently but one ear is affected, and in such cases the disease of the pharynx is usually found to be confined to that side. Sometimes this consists of only a superficial erosion. In many cases the ulceration is confined to the posterior wall of the pharynx, behind the velum palati, and, as in this location it rarely causes the patient much inconvenience, it may be overlooked if an examination with the rhinoscopic mirror is omitted.

The *subjective and objective symptoms*, and the course of syphilitic acute catarrhal inflammation, resemble so closely the idiopathic form that a description of the same seems unnecessary in this place. Schwartze (*op. cit.*, p. 134) asserts that an impairment in the conduction of sound through the bones occurs regularly at an early period in this disease, and adds that it is not known to what this is due. The present writer has, however, seen a number of cases of this affection in which the bone conduction remained unimpaired throughout.

With regard to the *treatment*, it is only necessary to state that, in addition to the local measures usually employed in the idiopathic form, a course of antisyphilitic remedies will be found necessary to cure the disease of the ear and the pharynx. In this connection it may be well to point out the danger arising from using, on healthy persons, catheters and other instruments that have been employed on syphilitic individuals. Boiling the instruments in a five-per-cent. solution of carbolic acid may possibly be sufficient to destroy the virus, but in the opinion of the writer it would be far safer to provide each patient with instruments for his exclusive use.

Chronic Aural Catarrh.—With regard to this disease, Wilde (*op. cit*., p. 254) says: "All the cases I have seen of this affection occurred in young men, and generally those of fair complexion and blue eyes, who had had primary sores upon the genitals from six to twelve months previously, which sores were rather of a deceptive character, so that mercury was seldom given, in the first instance at least, in a legitimate form. Sore throat, papular eruptions, copper-colored blotches, fissures and ulcers of tongue, with loss of strength and slight nocturnal pains, existed previous to the aural affections, which should, I think, be ranked as tertiary symptoms. In almost every case I have witnessed the disease appeared suddenly as an eruption was fading off; in two it came on at a later period and was accompanied by loss of hair; in most it appeared in the upper and middle ranks of life. In some cases there is at first a sensation of fulness in the head, and often vertigo upon stooping or rising up suddenly, but in no instance have I seen it accompanied by acute pain. Tinnitus is not always present." In all of the cases observed by Schwartze, except two, in which the patients positively stated that the disease began with lancinating pain, and in all seen by the writer of this article, the disease was insidious in its approach, and pain in the ear was absent throughout its course. Pain in the bones of the head was, however, occasionally complained of. Tinnitus was present in nearly all the cases, though it was not always very annoying.

As regards the appearance of the drum membrane Wilde says: "Upon inspection the amount of redness and vascularity will be found much greater than in subacute myringitis, and in this consists one of the chief characteristics of this disease, that while it is unaccompanied by local pain, the membrana tympani will be found to present an amount of redness equal to, and sometimes exceeding, that seen in acute myringitis.* The redness has generally, however, a brownish hue in the syphilitic form. There is not at first much loss of polish, but in a short time the membrane assumes a fuzzy appearance. Both ears are usually attacked at the same time." Schwartze (*op. cit*., p. 264), Roosa, and most of the more recent writers on this subject, on the other hand, have been unable to find in the appearance of the drum membrane in this disease anything that could be regarded as pathognomonic of its syphilitic character. Pomeroy[61] believes that it very frequently does not differ in appearance from that in non-syphilitic disease, but that signs of infiltration of the membrane, giving it a greater degree of opacity than would result from a non-specific inflammation, will cause one to suspect constitutional disease. In his opinion the most important aid, however, to diagnosis is the history. Sturgis (*Boston Med. and Surg. Journal*, June 3d, 1880) regards the infiltration of the tympanum, conjoined with the absence of vascular congestion, as characteristic of syphilitic catarrh of the middle ear.

The Eustachian tube is usually easily permeable, at least by the aid of the catheter. The sounds heard on auscultation are usually dry and broad, but sometimes moist râles are heard. The inflation rarely improves the hearing even for a short time, though it sometimes temporarily arrests the tinnitus. The lining membrane of the pharynx is nearly always hyperæmic, and very often superficial ulcers are found on the arches of the palate and the tonsils. The nose is usually not markedly diseased. The impairment of hearing, which is commonly already well advanced when the patient comes under treatment, in the majority of cases goes rapidly from bad to worse, so that in the course of a few months only loud speech can be heard close to the ear. In the remainder the progress is much slower, and instead of months years may pass before this state is reached. In a case seen by Schwartze a sudden and great increase in the hardness of hearing followed a blow on the head. In many of the cases, even in persons under thirty years of age, an impairment or loss of bone conduction occurs at an early stage of the disease when the tick of the watch is still heard at some distance from the ear. In several of Schwartze's cases even the large tuning-fork C was heard indistinctly or very faintly when placed on the vertex.

Our knowledge of the pathological anatomy of syphilitic catarrhal inflammation is very imperfect, as it must be of all diseases which are not fatal. Moos[38] found in a case of deafness, supposed to have been due to syphilis, beside adhesive inflammation of the labyrinth and the deposit of chalky concretions on the membranous semicircular canals and sacs, inflammatory changes in the drum membrane, thickening of the pale mucous membrane of the middle ear, and ankylosis of the malleo-incudal joint and of the stapedio-vestibular articulation, all of which have been seen often enough in non-syphilitic cases. In Toynbee's case ("Catalogue of the Museum," No. 512), which occurred in a man about forty-eight years of age, the deafness began five years before death. Right ear: loud voice close to the ear. Left ear: total deafness. The deafness commenced while he had a severe ulceration of the fauces from syphilis. Post mortem: Right ear: ankylosis of the stapes; the articular surface of os Sylvii much flatter than usual; adhesion between the anvil and hammer; tensor tympani atrophic; membrane of round window thickened; cochlea of a deep-red color. Left ear: ankylosis of stirrup; thickening of membranous vestibule. Schwartze (*op. cit*., p. 135) surmises that the pathological change in the syphilitic cases is a periostitis, and Roosa[39] thinks that this view is correct. The last-named author is also of the opinion that there may be also, in the course of the later periods of the disease, a syphilitic exudation into the tympanum and about the ossicles; and that it may be said, in general, that the syphilitic diathesis seems to cause a more rapid proliferation of tissue, and one that is less amenable to treatment. Kirchner[40] has had the opportunity of examining microscopically the mucous membrane of the promontory of a man, twenty-nine years of age, who four years before his death had had a primary sore and later an inflammation of his middle ear with amber-colored exudates in the tympanic cavity. At the autopsy a moderate amount of bloody serous exudation was found in the tympanic cavity and some congestion of the mucous membrane of the promontory. He found the mucous membrane somewhat thickened in some places and the walls of the blood-vessels and the tissues around them infiltrated with small cells. The calibre of some of the larger branches of the arteries was much narrowed by a syphilitic endarteritis, and some of the larger arteries were entirely obliterated by an inflammation of both the intima and the adventitia. In the periosteum corresponding to the most diseased places in the mucous membrane were found patches of newly formed bone, the result of a periostitis similar to that found in other bones. In the Haversian canal of the bone were seen patches of thickening together with an infiltration of small cells and heaps of pigment. In the bone itself were hollow places filled with detritus.

Woakes[41] claims to have seen through the drum membrane a gummatous exudation in the tympanic cavity.

From what has been said with regard to the symptoms, it must be evident that there is none by which we can positively distinguish chronic catarrhal inflammation of the middle ear, due to syphilis, from that arising from other causes. The supervention of symptoms indicative of disease of some part of the acoustic nerve (impairment or loss of bone conduction, etc.) in the earlier stages of the disease, occurs unquestionably much more frequently in the syphilitic cases than in others, but is by no means a positive sign of the specific character of the disease. Such symptoms, when present, especially in young and middle-aged persons, should, however, arouse our suspicion as to the presence of syphilis, and lead us to make a very careful search for other symptoms of this disease. Only when such are found, or a clear history of constitutional syphilis can be obtained, are we justified in making the diagnosis of syphilitic ear disease.

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* Wilde applies the term myringitis to the disease now generally called acute catarrhal inflammation of the middle ear.

The prognosis of the syphilitic chronic middle-ear catarrh is, on the whole, even less favorable than that of the idiopathic form. Nearly every writer has met with some cases in which, under judicious local applications and a thorough course of antisyphilitic remedies, the hearing was improved and even restored. But such cases are, after all, according to the writer's experience, rarely encountered—outside of the books. To arrest the progress of the disease is about the most we can hope for.

In the treatment of this disease it will be found necessary, in addition to the usual remedial measures for the ordinary chronic catarrhal inflammation, to resort to constitutional remedies. In all cases in which no doubt exists as to the diagnosis, the patient should be brought rapidly under the influence of mercury by inunctions or injections under the skin, and this should be kept up for a considerable period. Iodide of potassium may be given at the same time. The muriate of pilocarpine, in doses of gr. $\frac{1}{6}$ to gr. $\frac{1}{3}$ administered hypodermically, once daily for several weeks, has been of some service in the hands of Politzer, Lucae, and others, in cases complicated with disease of the inner ear.

Purulent Inflammation.—Among the writers on otology much diversity of opinion has always existed as to the occurrence of a syphilitic purulent inflammation of the middle ear. Thus, Frank[42] and Lincke[43] describe an otitis interna the result of lues. In this form, they say, the inflammation and ulceration extend from the throat and nose to the ear, are accompanied by great pain, and often terminate in suppuration of the middle ear, destruction of the tympanal membrane, and caries of the temporal bone. Wilde (*op. cit.*, p. 252), on the other hand, says that under certain circumstances such a disease may, no doubt, occur, although he himself has never seen such a case and has not met with a well-authenticated instance of it recorded. Kramer[44] doubts that syphilis can cause a specific disease of the ear, and adds that he has never in his own practice, or in that of others, observed such cases, and Erhard[45] is of the same opinion. Virchow[46] mentions, as the result of syphilis, primary purulent inflammation of the tympanic cavity; stricture of the Eustachian tube resulting from cicatricial closure of its pharyngeal mouth; and caries of the temporal bone. In the treatises on diseases of the ear of more recent date, but little can be found relating to this disease. Politzer (*op. cit.*, p. 330) devotes less than a page to it, and Gruber (*op. cit.*) merely mentions syphilis as one of the causes of otitis media purulenta. Pritchard,[47] in speaking of the affections of the middle ear caused by syphilis, says that they are of comparatively rare occurrence, and that in some cases suppurative catarrh is set up with perforation, etc. Pomeroy (*op. cit.*, p. 239) thinks that syphilis may interrupt the progress of the disease toward recovery, and Schwartze (*op. cit.*, p. 176) only says, with regard to this disease, that under the influence of constitutional syphilis the suppuration may become chronic. Troeltsch, Roosa, Burnett, and others make no mention of it whatever. It may also be stated here that the number of cases of this disease reported in the medical journals within the last twenty years is exceedingly small.

Of our present knowledge of this form of otitis media purulenta it cannot be said that it is much more definite than it was in Lincke's time. Schwartze has seen cases in which syphilitic disease of the fauces was absent, but most other writers, including the present, have found such an affection existing in nearly every case. The disease of the naso-pharyngeal cavity may be any one of the various manifestations of constitutional syphilis met with in this locality, or may be a primary chancre due to the accidental inoculation of this part during catheterization of the Eustachian tube. Fortunately such accidents have but very rarely occurred.

With regard to the symptomatology and course of the purulent otitis media, most authors are agreed that they do not differ essentially from the non-syphilitic form. Buck,[15] while not disputing this statement with any great degree of positiveness, owing to the scantiness of the material which has come under his observation, cannot help feeling that, with increased experience and a closer study of this particular class of cases, we shall in time learn to recognize in these parts textural lesions as distinctly characteristic of syphilis as are most of its external manifestations. In one of the cases reported by him (Case XII.), a second perforation developed in the drum membrane more than two months after the first, through a melting process similar to that observed so frequently in the velum palati, and he regards this occurrence as totally different from anything that he has ever observed in any case of non-syphilitic inflammation of the middle ear. Probably a similar melting away of a limited area of the drum membrane took place in another of his cases (Case XI.). In neither of these cases was there any evidence of pressure from within. In the first-mentioned case caries and facial paralysis were subsequently developed, while there was no evidence of interference with the free escape of the pus formed, and this Buck regards as certainly not in harmony with the ordinary course of non-syphilitic otitis media purulenta acuta. Politzer and others frequently noticed a high degree of deafness in these cases, caused by the frequent simultaneous occurrence of syphilitic disease of the labyrinth. Of the occasional occurrence of condylomata and ulcers in the external canal, in connection with this disease, mention was made in the first part of this article. In the cases observed by the present writer the symptoms were precisely those of the non-syphilitic form, and the course and termination of the disease differed in nowise from the other. Ulceration of the mucous membrane, with caries and necrosis of the walls of the tympanic cavity, the mastoid process, and the petrous portion, and facial paralysis, may, according to Politzer, occur under unfavorable circumstances or inappropriate treatment, and end fatally through some intracranial affection. Caries has been observed in this form probably no more frequently than in the non-syphilitic forms.

Fatal hemorrhage from erosion of the internal carotid artery, caused by caries of the canal of the vessel, has been observed in syphilitic, as well as in non-syphilitic, subjects. Thus we find in the nineteen cases of fatal hemorrhage collected by Hessler,[48] two in which syphilis was present. One of these cases (reported in full by Tüngle in the *Deutsche Klinik*, No. 23, p. 223) occurred in a patient suffering from tertiary syphilis. Two years after he had come under observation he had a sudden profuse hemorrhage from the left deaf ear, and four months later, after repeated hemorrhages, the patient died. An autopsy revealed a complete destruction of the interior of the petrous portion of the left temporal bone. The membrana tympani and ossicles were wanting. Of the other case (described by Pilz in his dissertation, "De Arteriæ Carotidis utriusque Ligatura," Berlin, 1865) it is only known that, after severe pain in the region of the right ear, without objective symptoms, a sudden and copious hemorrhage occurred from this ear; subsequently the blood was mixed with pus. The patient had syphilis, and a fistula on the posterior wall of the pharynx from which pus escaped. After repeated hemorrhages Billroth first ligated the right and then the left carotid. The patient died under symptoms of anæmia. The autopsy showed extensive caries of the lower wall of the carotid canal, exposing the vessel. The eroded spot in the artery measured 8 mm. in length and 6 mm. in breadth.

Metastatic irido-choroiditis of the eye on the same side as the purulent middle-ear disease, developed in a syphilitic subject, observed by the writer of this article.[49] In this case the ear disease was arrested and the hearing restored under general treatment alone.

As regards the *diagnosis*, the writer must confess that he knows of no aural symptoms by which the syphilitic form of this disease can be distinguished from the ordinary form. Woakes[41] thinks that the caries due to syphilitic purulent inflammation of the middle ear frequently has this distinguishing feature: the caries is symmetrical, that is, there is a corresponding lesion in both ears. In this disease, as in the diseases previously described, the presence of other symptoms of syphilis can alone decide the diagnosis.

Of the *pathological anatomy* of syphilitic suppuration of the middle ear we know but little. Quite recently Moos and Steinbrügge[50] have had the opportunity to examine both temporal bones of a case of tertiary syphilis. Moos first saw the patient fourteen years before his death. At that time the faucial orifices of the Eustachian tubes were closed by numerous thick, radiating, fibrous bands, so that the ventilation of the drum cavity must have been almost impossible; notwithstanding, there was no demonstrable deviation in the plane of the drum membrane, in the position of the handle of the hammer, or in the cone of light. Strange to say, the patient never complained of subjective noises nor of dizziness. Bone conduction was always sufficiently preserved to detect the loud tick of a watch and the tuning-fork; the capacity for hearing speech was, however, so much reduced that ordinary conversation was not heard beyond one metre. The patient remained under Moos' treatment for about two years, and then passed from under his observation till a week before his death. At this time he was examined by Steinbrügge, who found that he was now able to hear spoken words only in close proximity to the ears; a watch of twelve metres normal hearing distance was heard merely on contact in the right ear, and not at all in the left. Tuning-fork A′ applied to the forehead was not perceived, applied to the teeth it was heard in the left ear. The otoscopic examination of the right ear revealed a cicatrix in the inferior posterior quadrant of the membrane; the external canal of the left ear contained pus, and there was a round, medium-sized perforation directly under the handle of the malleus. Post mortem, the following conditions were found: Syphilitic caries of the skull and hard palate. Chronic pneumonia. Amyloid degeneration of the spleen, kidneys, and liver. *Right temporal bone:* The greater part of the mastoid process was sclerosed. The mucous lining of the remaining cells was slightly injected. The Eustachian tube (a portion of the pharyngeal orifice was missing) was patent throughout. The tympanum contained a quantity of pus. The mucous membrane was thickened. The drum membrane was in an atrophic state. The bony roof of the labyrinth was hemorrhagically infiltrated. *Left temporal bone:* Greasy pus in external canal. Membrana tympani perforated. The mastoid process was sclerosed and of ivory-like hardness. The mucous membrane of the tympanum was very much thickened, and enveloped all structures contained therein. The cavity was filled with a secretion composed of pus cells and giant cells. The Eustachian tube (also here a portion of the pharyngeal orifice was wanting) was pervious. *Carotid artery and osseous portion of Eustachian tube:* There was no noticeable change in the outer and inner coats of the artery on either side, not even in the part where the bony partition between the artery and the Eustachian tube measured but 0.087 mm. in thickness. The mucous membrane of the Eustachian canal was normal, but the periosteum of the osseous portion in a medial direction was changed and thickened in a manner to be described below. *Periosteum and bones of middle and internal ear:* In the bony floor of the tympanum and below the cochlea, as well as in the roof of the tympanum, in the bone over the semicircular canals, and in the lateral wall of the osseous portion of the tube, were found markedly dilated medullary spaces, not only enclosing the usual normal contents, but also invariably filled—sometimes more, sometimes less—with larger or smaller groups of cells enclosing blood corpuscles, and also with a conglomeration of yellow or yellow-brownish pigment. Evidently we had to deal here with the products of a metamorphosis of blood extravasation, the result of rupture of the thin-walled vessels contained in the medullary spaces. In the anterior wall of the bony vestibule, and in the osseous tissue anterior and posterior to the second curve of the Fallopian canal, were noticed several spaces in the bone, varying in size up to 3 mm. in length and 2 mm. in width on the left side, and 2 mm. in length and 1½ mm. in width on the right side. A similar condition was observed in the bone tissue below the first turn of the cochlea on the right side. The cavity here was circular; its diameter measured 2 mm. The contents of these spaces clearly demonstrated two separate stages in the pathological process. In the early stage these spaces were filled with a fibrous network, which in several sections showed unmistakable connection with the periosteum of the labyrinthine wall. The meshes of this network were filled with vessels more or less numerous, and a small-celled infiltration. The condition demonstrating a later stage, however, mostly predominated. Here the meshes were filled with yellowish coagulated masses, composed to a limited extent of blood corpuscles and large round cells, and mainly of fat globules and fatty-degenerated cells stained black by the osmic acid. In addition, there were seen in many places, as indications of the earlier stage, the remains of fibres of this network in connection with the periosteum of the labyrinth mentioned above.

The condition of the periosteal covering of the promontory on both sides is worthy of special notice. Very much thickened, at places to 0.7 mm., the presence of numerous cavities imparted to it a cavernous appearance. The spaces were here and there lined with a low cylindrical epithelium, and in some places were filled with a tissue composed of fine fibres enclosing coagulated fibrin and fatty-degenerated cells. At first glance these spaces gave the impression of gland tissue; closer examination, however, proved them to be numerous circumscribed foci of inflammatory products undergoing retrogressive changes. The presence of smaller and larger portions of bone, cut off from the main bony mass of the promontory by strangulation of the proliferating periosteum, deserves additional notice. In some portions of the sections these spicula of bone were arranged in rows separated from each other by narrow bands of periosteal tissue. In other parts the proliferating periosteum produced deep indentations in the bone. The periosteum of the canalis pro tensore tympani and that lining the delicate canaliculi of the plexus tympanicus presented a similar pathological appearance.

In their comments on the above the authors say that, taking into account the fact that in their case they had to deal not with a fresh gummous neoplasm but with the later consequences of periosteal proliferation, the above-described changes in the periosteum with their consequences would show a close correspondence with the description given by Rindfleisch of syphiloma ossium. Several hemorrhagic extravasations were found in the perineurium of the tympanic plexus and these as well as the proliferation of the periosteum explained, they thought, the genesis of many of the so-called pure nervous otalgias occurring without objective signs of ear disease in the course of constitutional syphilis. They are also of the opinion that in cases of aural trouble without objective symptoms, occurring in syphilitic subjects, in which the functional examinations pointed to a peripheral disease of the ear, the diagnosis of periostitis of the labyrinthine wall might thereafter be made with a great degree of probability. The attacks of otalgia would serve as an adjunct in making the diagnosis.

The penetration of the proliferating periosteum into the thin, long septum dividing the osseous portion of the tube from the carotid canal will afford an explanation for those fatal hemorrhages which occasionally occur in syphilitic subjects, and which are attributable to caries. The observed changes in the floor of the right tympanic cavity invite attention to the possible involvement of the bulbus venæ jugularis, similar to that of the carotid in the dangerous hemorrhages occurring in tertiary syphilis.

Among other changes found may be mentioned: the absence of a not inconsiderable number of fibres of the right facial nerve; the presence of rust brown, homogeneous deposits between the fibres of the acoustic nerve; the destruction of ganglion cells and nerve fibres in Rosenthal's canal in the first turn of the cochlea, and hemorrhagic extravasations between the nerves of the modiolus of the same side; and the absence of the outer cells of Corti, which may, however, have been due as well to the action of reagents as to a pathological process.

In marked contrast with the great changes found in the above case was the condition of the structures of the ears in a case observed by Betz,[51] who with von Troeltsch made the autopsy. A man, thirty-six years of age. Otorrhœa and moderate hardness of hearing since infancy. Eight years before death he contracted syphilis, of which symptoms were still present five years before he died. A few years after infection there was a great increase in the hardness of hearing. During three years of his life he was totally deaf.

Autopsy: The right ear was free from caries. The left ear revealed otitis media purulenta with kidney-shaped perforation of the drum membrane. The lining membrane of the tympanic cavity was much thickened and injected. Ulceration of mucous membrane or exposure of bone could not be discovered. The anvil and stirrup were completely preserved and freely movable. There was no caries anywhere. With the exception of a slight thickening of the contents of the vestibule, and uncommon abundance of otoliths, the inner ear seemed normal. In his comments on the autopsy von Troeltsch points out that it does not in the least explain the total deafness, the cause of which must therefore be sought for in the brain.

In the other cases examined after death, only such alterations were found as are seen in purulent inflammation of the middle ear in non-syphilitic subjects.

The *prognosis* is favorable only in the beginning of the ear disease, in the milder cases, and in persons of strong constitution; but when this disease occurs in cachectic individuals, or is complicated with polypi and caries, or the hearing is totally destroyed, the prognosis is very bad. Yet recovery has been observed under judicious general treatment in cases which seemed hopeless.

The *local treatment* usually adopted for the non-syphilitic form—viz., thorough and frequent cleansing with warm salt water when the otorrhœa is at all copious; instillation of warm nitrate-of-silver solution or of alcoholic and watery solutions of corrosive sublimate (as recommended by Bürkner), after all pain has ceased; the removal of granulations with the wire snare or with the sharp spoon, etc.—will be found of service as well in the syphilitic form. That in this, as in all syphilitic ear affections, a thorough course of antisyphilitic remedies, perhaps combined with tonics and a generous diet, is as necessary as the local treatment for the ear affection, is the experience of all who have written on the subject.

Neuralgia of the middle ear, due to constitutional syphilis, is an extremely rare disease. Usually syphilitic disease of the faucial orifice of the Eustachian tube or of some part of the pharynx or larynx is present at the same time, and is probably the starting-point of the pain in the ear. The entire absence of objective symptoms of disease of the tympanic cavity, and the paroxysmal character of the pain, will establish the diagnosis. Moos, as we have seen, thinks that the hemorrhage in the neurilemma of the plexus tympanicus, as well as the proliferation of the periosteum which he found in one of the cases examined by him, explains to us the genesis of many cases of so-called pure "nervous otalgia," occurring without objective signs of ear disease in the course of constitutional syphilis. Kirchner[40] also believes that the otalgia is due to a periostitis and disease of the vessels of the tympanic cavity. The treatment must be directed against the constitutional disease; and if disease of the pharynx or larynx is present, applications to these parts will also be of benefit. Of these, cocaine will probably give greater temporary relief than any other remedy. Schwartze has found of especial use gargles of a solution of the bromide of potassium in such cases.

THE EUSTACHIAN TUBE.—Instances of primary syphilitic sores at or near to the pharyngeal orifice of the Eustachian tube have been observed, according to Politzer, by Ricord, Lancereaux, Blanchet, Fournier, Bouquay, Laboulbène, Baratoux, and others. J. Solis Cohen ("Diseases of the Throat," p. 113) says that he has seen a fearful case of ravage from a chancre (locality not specified), communicated by the incautious use of the Eustachian catheter. Chancres of the naso-pharyngeal cavity are, however, according to all writers, of extremely rare occurrence. The contagion is probably always conveyed through the Eustachian catheter. The sores present no characteristic features. The floor of the chancre is usually indurated and the lymphatic glands at the angle of the lower jaw are commonly much enlarged. The sore, as a rule, causes but little pain. Primary chancres of the pharynx, like erratic chancres occurring in other parts, are usually single. The treatment must consist of mercury administered internally or by inunction, and local application of iodoform or iodol; but if the sores prove intractable, they should be touched with the acid nitrate of mercury or other caustics.

Constitutional syphilis rarely causes isolated affections of the Eustachian tube. As a rule, the adjacent mucous membrane is the seat of the same morbid process. The earlier manifestations of syphilis met with in this locality are erythema, mucous patches, and superficial ulceration. The erythema may be generally diffused over the whole mucous membrane, or distributed in irregular patches between which the mucous membrane is of normal color. While not infrequently the syphilitic erythema presents no features by which it can be positively distinguished from the simple catarrhal inflammation of the mucous membrane, a symmetrical distribution of the erythematous patches is regarded by many authors as strong evidence of the syphilitic nature of the disease. Mucous patches may occur in any part of the naso-pharynx, and have been occasionally observed on the tubal prominence. They present themselves as small, round, slightly elevated patches of a grayish-white color, surrounded by a zone of more or less inflamed mucous membrane. Ulcers are comparatively seldom found in the naso-pharyngeal cavity in the early part of the secondary stage. They are usually quite shallow, and are nearly always the result of the breaking down of mucous patches. Usually the ulceration begins in the middle of the mucous patch, and gradually spreads to its periphery.

Excrescences resembling pointed condylomata have been observed on the pharyngeal mucous membrane in two cases by Schwartze. In connection with the morbid states above briefly described, we very often find redness and more or less œdematous swelling of the mucous membrane of the greater part of the cartilaginous portion of the Eustachian tube. Frequently there is also a great increase in the secretion from the mucous membrane, so that then on inspection the upper portion of the pharynx is found covered by or filled with it.

The subjective symptoms are those of ordinary catarrhal inflammation of the Eustachian tube, viz., slight pain in the throat, extending to the ear, especially on swallowing; pressure and a sense of fulness in the ear; more or less impairment of hearing, and subjective noises. Vertigo and headache are rarely complained of. Auscultation, during inflation of the Eustachian tube through the catheter, commonly reveals distant moist râles, which cease after the secretion has been forced into the pharynx. The drum membrane shows changes here, as in simple catarrh of the tube, only after the ventilation of the tympanic cavity has been interfered with for some time, and these consist chiefly in a retraction and dulness of this structure.

The *prognosis* is always favorable under proper management of the case.

The *treatment* of the diseases of the Eustachian tube occurring in the secondary stage consists in the administration of mercury; the cleansing of the naso-pharyngeal space by means of the posterior nasal syringe or an atomizer; topical applications of weak solutions of corrosive sublimate or nitrate of silver to the mucous membrane of the naso-pharynx; and frequent inflation of the Eustachian tube through a catheter or by Politzer's method.

In the tertiary stage, gummy tumors and deep ulcers, sometimes involving the cartilage of the tube, are occasionally met with at or within the faucial orifice. According to Zauf,[52] the plica salpingo-pharyngia is most frequently the seat of gummata. They present themselves as round tumors of a yellowish red or red color, smooth surface, and a broad base, varying in size from a pea to a hazelnut. The deep ulcerations found in this stage of the disease are probably always the result of the breaking down of gummatous deposit. Such ulcers are, according to Schwartze, not infrequently found on the tubal prominence and at the entrance to the faucial orifice, together with similar ulcers on the septum narium, choanæ, fornix, posterior surface of the velum palati, etc., in cases in which the usual inspection without the rhinoscopic mirror fails to arouse a suspicion as to their presence. They have, however, been seldom found beyond the mouth of the tube. These ulcers frequently spread with great rapidity and cause extensive destruction. If seated on or near the mouth of the tube, a complete growing together of its walls may occur during cicatrization of the ulcer. The aural symptoms caused by an ulcer on or near the mouth of the tube do not differ from those described under the head of diseases of the secondary stage. Pain referred to the ear is, however, more frequently complained of in connection with ulceration than with erythema and mucous patches on or near the mouth of the passage.

In the treatment of the tertiary symptoms our chief reliance must be placed on iodide of potassium alone or in combination with mercury. Locally, nitrate of silver, in substance or in solution, the acid nitrate of mercury, iodoform, or iodol, may be applied daily or less often. Thorough cleansing of the ulceration should precede the application of the remedies named.

Hyperostosis and exostosis of the osseous part of the Eustachian tube are, according to Gruber,[53] sometimes caused by syphilis. This is, however, denied by other writers.

Mastoid Process.—*Osteo-sclerosis* and *hyperostosis* of the mastoid process are, according to Schwartze, sometimes caused by syphilis. We know of no signs by which a differential diagnosis can be made between the idiopathic and syphilitic forms of these diseases. A course of antisyphilitic treatment will, however, soon decide which form we have to deal with. Gummata of the mastoid cells are extremely rare. Superficial and extensive caries of the outer cortex of the mastoid process, without disease of the middle ear, occurs, according to Schwartze, only as the result of syphilitic or tuberculous periostitis. The syphiloma or gumma may develop under the picture of a periostitis of the mastoid process. It may break down in parts and simulate the feeling of fluctuation. Its development may be very rapid, and it may disappear as quickly under antisyphilitic treatment.[54]

The Inner Ear.—Of the affections of the organ of hearing caused by syphilis, diseases of the inner ear are probably least frequently met with. These diseases usually make their appearance toward the latter part of the secondary stage, or at a still later period. According to Politzer, they are sometimes developed simultaneously with secondary skin or throat affections, and in one case observed by him, a disease of the inner ear appeared as early as the seventh day after the primary infection. The same author has also recorded a case in which labyrinthine disease was developed simultaneously with a gumma of the skull, twenty-one years after infection; and the present writer has notes of a case in which sudden and absolute deafness of one ear, in connection with naso-cranial osteitis, occurred twenty-six years after the primary disease, and after an interval of more than twenty-five years of complete freedom from symptoms of constitutional syphilis. Hutchinson ("Syphilis," p. 32), on the other hand, has no knowledge of any form of deafness due to syphilis which occurs in the tertiary stage of the acquired form.

The diseases of the labyrinth may be developed alone or in association with tympanic diseases. Frequently they supervene on pre-existing catarrhal or purulent inflammation of the middle ear.

The *symptoms* of syphilitic disease of the labyrinth do not differ essentially from those of the affection of this part due to other causes. In this form, as in diseases of the labyrinth in general, a marked diminution or total loss of the hearing power in one or both ears occurs, usually more or less suddenly. Subjective noises, of a variable nature, often of great intensity, sometimes precede the onset of the deafness, but more commonly are developed at the same time. They are rarely entirely absent. Vertigo and unsteadiness of gait sometimes usher in the attack, but more frequently these symptoms follow the deafness. Nausea, vomiting, headache, and weakness in the limbs are also early symptoms in many cases. Pain in the ear very rarely accompanies the attack. Inspection of the drum membrane will in many cases give a negative result, while in others it will reveal the changes usually found in connection with chronic catarrhal disease of the middle ear. Evidences of acute inflammation of the tympanic cavity are usually wanting. The air douche through the catheter commonly shows a pervious Eustachian tube, and the sounds heard on auscultation are generally broad and dry.

A closer examination of the hearing power in these cases shows that besides the impairment of hearing for the voice, the perception of sounds through the bones of the skull is either greatly diminished or entirely wanting. In cases in which both ears are deaf, vibrating tuning-forks placed on the vertex or between the teeth are usually not heard at all, and in cases in which only one ear is diseased, the tuning-forks are heard most distinctly in the healthy ear and never only in the affected ear. Placed on the mastoid process of the affected side, the tuning-fork (the writer usually employs for this purpose a small C^2 fork of 212 vibrations a second), if heard at all, is heard from this part less long than normally in persons of the same age. In cases of great impairment of hearing for the voice the employment of Rinné's test nearly always shows the predominance of aërial over bone conduction; while in total deafness for the voice small tuning-forks are not perceived at all, but very large ones, when struck with much force, are heard when placed on the mastoid process. The examination with the piano or tuning-forks of different pitch, not infrequently shows that the perception of certain tones of the scale, usually the highest, is diminished or destroyed, or that whole groups of tones are not perceived. In a case observed by Knapp,[55] tuning-forks of high and low pitch were not heard, while those of medium pitch were perceived; neither the highest four ($e'''' - a''''$) nor the lowest four tones ($A^2 - D^1$) were heard; the octave next to the highest was heard, and that above the lowest tones only feebly. The power of appreciating low tones is the last to suffer and the first to recover in most cases, so that these will be heard when the high ones are not heard at all, or false, or doubled.[39] In a case reported by Blake and Walton,[56] a tuning-fork (562 v. s.) was heard in the left ear one-fifth higher than in the right; and sixteen days later, tuning-forks (560 v. s. and 1,200 v. s.) which were heard through the air, and the tone reproduced by the patient's singing, normally in the right ear, were heard and reproduced below their pitch in the left ear; otherwise the hearing was equally good in both ears.

The course of this disease is not always the same in all cases. While the clinical picture usually presented is that of a very rapid decline of the hearing power, till complete deafness is reached, the progress in the impairment is in some cases comparatively slow. In cases observed by Politzer, nearly total deafness was present three days after the onset of the disease. Concussion of the head, sometimes of slight degree, will occasionally cause a rapid increase in the deafness in these cases (Politzer, Troeltsch, Urbantschitsch, Gruber). Fluctuation in the deafness is less often observed in this disease than in affections of the middle ears. The vertigo, unsteadiness of gait, and headache generally continue for a few weeks or months, and then gradually disappear. The hardness of hearing unfortunately often remains, and in the few cases which end in recovery the improvement takes place very slowly.

Syphilitic disease of the labyrinth cannot be distinguished from disease of this part due to other causes, either by the aural symptoms or by the hearing tests employed. The sudden onset of the disease and the rapid progress of the deafness for the voice, together with the absence of bone conduction, are regarded by many authors as peculiar to the syphilitic form of this disease. The present writer has, however, seen quite a number of cases presenting such a history in which syphilis was entirely out of the question, and therefore cannot regard the above-mentioned symptoms as characteristic of syphilis of the inner ear. If, however, the train of symptoms described occurs in connection with undoubted evidence—in the skin, the eye, or other parts of the body—of constitutional syphilis, or in an individual with a clear history of syphilis, we may assume with much confidence that the labyrinth disease is due to the invasion of syphilis. In the absence of a history, or of other symptom of syphilis, our suspicion as to its presence should be aroused, nevertheless; and we should make a searching examination for its presence in all cases of sudden loss of hearing, unaccompanied by pain, occurring in vigorous young or middle-aged persons whose nervous system was in a healthy condition previous to the attack, and in whom traumatism or other plausible causes of the deafness can be excluded (Schwartze). In several of such cases in which syphilis was absolutely denied, Politzer was enabled by a rigorous search to prove conclusively that constitutional syphilis was the basis of the ear disease. In this connection it should also not be forgotten that an outbreak of tertiary symptoms may occur after a long period of apparently good health.

The differential diagnosis between this disease and affections of the middle ear involves no great difficulty in recent cases. The absence of objective symptoms of middle-ear disease, and the results of tests with tuning-forks and the piano will decide the diagnosis. The case is, however, entirely different if well-marked signs of middle-ear disease are present, and more particularly if both ears are diseased and the loss of hearing has developed gradually. Under these circumstances the results of even the most patient examination with tuning-forks and the piano will often leave it undecided whether one or the other or both parts are diseased. The supervention of syphilitic disease of the labyrinth upon middle-ear disease may be inferred from the history of the case, the suddenness of the increase in the hardness of hearing, and the result of the hearing tests previously mentioned.

So far as is known to the present writer, Roosa (*op. cit.*, p. 610) is the only author who thinks that we are justified in going a little farther in our classification than merely to state that this is a disease of the labyrinth. We may perhaps, he says, diagnosticate disease of the cochlea, or at least say that the affection of the cochlea is predominant in certain cases (great impairment of hearing, inability to hear certain tones, and the production of false ones), just as we may speak of disease of the semicircular canals, when vertigo and staggering gait are the predominant symptoms. To such cases he applies the name of syphilitic cochleitis.

With regard to the pathological anatomy of syphilitic disease of the labyrinth, it must be admitted that our knowledge is still in a very unsatisfactory state. Indeed Schwartze, than whom no one is better qualified to express an opinion on this subject, does not hesitate to say that we have no anatomical knowledge whatever of this disease, and that the pathological changes in the labyrinth found by Toynbee, Gruber, Moos, Politzer, and others, of which a brief account will be given farther on, cannot be regarded as specific, since the same alterations occur in non-syphilitic cases. The condition of the organ of hearing found post mortem in individuals in whom syphilis and ear disease were known to have existed, was as follows: In a case of secondary syphilis, with catarrh of the middle ear, described by Voltolini,[57] there was found hyperæmia of the vestibule, of the commencement of the cochlea, and of the horizontal semicircular canal, and hyperostosis confined to the parts surrounding the fenestra ovalis. Gruber[58] found in a syphilitic subject who had become suddenly totally deaf, and who died from typhus fever, considerable hyperæmia of the lining membrane of the tympanic cavity and of the membranous labyrinth, which appeared much thickened. The fluid in the labyrinth was abundant in quantity and bloody in color. It is not stated that a microscopic examination was made. Whether the changes found in this case were the result of syphilis or of the typhus must remain undecided.

Moos[38] made an examination of the right petrous bone of a woman, forty-nine years of age, who had been very deaf on this side and blind in her right eye since her seventeenth year. The deafness and blindness were attributed by her to washing her head while in a state of perspiration. In the history of the case it is said that she had been treated for syphilis, but whether the infection occurred before or after the development of the deafness is not stated. She died from intracranial disease. At the autopsy, made by Professor Arnold, parts of the right parietal bone were found to be atrophied in consequence of gummy tumors. There were gelatinous œdema of the pia mater and hydrocephalus internus. In the right corpus striatum was found a fresh diffuse hemorrhage. Old syphilitic scars were seen in the liver. The examination of the petrous bone, made by Moos, showed, besides alterations in the drum membrane and in the tympanic cavity, rarefactive osteitis in the posterior semicircular canal. The stapes was firmly united with the oval window. The membranous structures of the vestibule and the membranous semicircular canals were in part intimately attached to the periosteum by connective-tissue bands, with the exception of the posterior membranous semicircular canal, which was much thickened but not adherent to the periosteum. In those parts of the semicircular canals which could still be isolated, the epithelium and the connective-tissue membrane were no longer distinguishable. They were covered partly by innumerable large and small cells lying close together. The bands of newly formed connective tissue between the periosteum and the connective-tissue membrane were also infiltrated with cells. The form and structure of the membranous portion of the vestibule were obliterated by a thick layer of hyperplastic connective tissue which covered the membrane almost everywhere; in some central places of the membrane, where the tissue was less opaque and more reticulate, the described infiltration of cells could, however, be observed. Where the newly formed connective tissue was most abundant there were seen numerous isolated, and in some places aggregated, globular concretions of phosphate of lime. The lamina spiralis was of a lemon color, it was much thickened and appeared under the microscope very opaque, very vascular, and infiltrated with numerous cells; of its several zones only the dentate region could be made out.

Commenting on the above Moos says: "The above-described anatomical lesions of the organ of hearing furnish a sufficient explanation of the total deafness during life. Leaving out of account the myringitis which supervened toward the end of life, the deafness was due to the ankylosis of the ossicles and the chronic inflammation of the labyrinth. Very probably this condition resulted from secondary syphilis, although the microscopic data would not of themselves point to it as a specific cause. As far as I know, we have not as yet reliable anatomical signs of syphilitic inflammation of the labyrinth. We know too little of the pathological anatomy of the labyrinth to be able to decide this question."

In another case of constitutional syphilis examined by Moos,[59] in which violent subjective noises, vertigo, and pain in the bones of the skull were followed later by a remarkably rapid destruction of the hearing power, he found the following condition: The osseous substance of the petrous bone was sclerosed wherever it was examined. The middle ear was entirely normal in every part. The labyrinth alone showed pathological alterations. The periosteum of the vestibule was slightly thickened; the foot plate of the stapes was also thickened and immovable. The connective-tissue supports between the bony walls of the vestibule and the vestibular membranous structure were hyperplastic and infiltrated with small cells. The connective-tissue membrane itself of the membranous vestibular structures was likewise hyperplastic and infiltrated with small cells. The periosteum of the lamina spiralis ossea, as well as all the zones of the lamina spiralis membranacea, exhibited the same small-cell infiltration. The exudation consisted of small round cells, with a few oval ones containing a single nucleus, which were placed with regularity very close to each other. With regard to the degree of dissemination of the infiltration, it remains to be mentioned that the periosteum of the lamina spiralis ossea was much less infiltrated than that of the zona pectinata and Corti's arches; the two last-named regions were so densely infiltrated that but few of the teeth and of Corti's arches could be seen distinctly; on the other hand, the infiltration was more copious in the ampullæ and sacculi, and in the connective-tissue supports between them and the bony walls, than in the membranous semicircular canals. The trunk of the auditory nerve was intact.

According to Politzer,[60] recent investigations leave no doubt that, in cases of long duration, a chronic inflammation of the lining membrane of the labyrinth may result in a periosteal bone proliferation in the cavity of the labyrinth. The following case occurred in his own practice: The patient was a man, fifty years of age, who had been totally deaf for ten years in consequence of syphilis. In the right drum membrane two broad, ribbon-shaped stripes extended downward at an acute angle from the end of the handle of the hammer. Bone conduction was destroyed. Death was caused by phthisis pulmonalis. Autopsy: The ribbon-shaped stripes on the drum membrane proved to be ridges of horny, thickened epidermis. The lining membrane of the tympanic cavity and the ossicles were normal on both sides. In decalcified sections of the cochlea, pathological alterations were mainly found in the ganglion cells in Rosenthal's canal. Within these cells were seen small, round, granular cells without a distinct nucleus, and also oval and annular bodies, in only a few of which a nucleus could be recognized. (Atrophy and degeneration of the ganglionic cells in the ganglion spirale.) The modiolus showed in spots a reticular structure. In the spiral membrane, in the vestibule, and in the semicircular canals no changes were visible which could be interpreted as pathological.

Pathological alterations in the blood-vessels of the inner ear, similar to those described by Heubner as occurring in syphilis of the brain, have thus far been observed only in a case examined by Baratoux.

The *prognosis* must be guarded as regards the recovery of hearing. In acute cases of recent date recovery has occasionally followed the energetic employment of mercury and iodide of potassium; but in cases of gradual loss of hearing or in those of long standing, the prognosis is decidedly unfavorable. Politzer is of the opinion that the degree of deafness is not always decisive for the recovery of normal hearing, since recovery from total deafness has been observed; while, on the other hand, in milder cases, active antisyphilitic treatment not only fails to produce an improvement, but is, moreover, sometimes followed by an increase in the deafness. This author has also seen patients in whom the deafness came on while they were under the influence of mercury.

Treatment.—If the ear disease occurs during the earlier stages of constitutional syphilis, mercury should be used freely, preferably by inunctions, till the system is brought under its influence; after that the remedy must be continued in smaller doses for a long period. Mercurial baths, subcutaneous injections of corrosive sublimate, and the internal administration of calomel, blue pill, and other preparations of mercury, may be substituted for the inunctions when they are objected to. The iodide of potassium, alone or in combination with mercury, is especially useful in cases occurring during the intermediate or tertiary stage. Roosa has obtained very encouraging results from this remedy in very large doses (gr. cxx. to gr. ccclxix. daily), in cases in which smaller doses failed to produce any effect. He used, however, inunctions of the oleate of mercury at the same time. To avoid disturbance of digestion it will be found best to dilute the iodide largely with water, and to administer it in divided portions during meals. Tonics and a generous diet should be given with both the mercury and the iodide to patients in feeble health. Subcutaneous injections of the muriate of pilocarpine, in gradually increasing doses (gtt. iv. to xij. of a two-per-cent. solution), have also proved useful in this disease in Politzer's hands. He is of the opinion that it should be tried for from eight to fourteen days in all recent cases, and that mercury and iodide of potassium should be given only if at the end of the above-stated period no improvement is manifest. Lucae, Moos, Barr, Bacon, and others also speak highly of the effect of pilocarpine in these cases, and think it worthy of further trials. Lucae has also seen temporary improvement of hearing follow the application of the artificial leech.

In order to protect the diseased ears as much as possible against the injurious effect of noises, while undergoing treatment, the patient should be kept in a perfectly quiet room, away from the streets, and it may even be advisable to cover the ears and the side of the head with cotton batting. If disease of the middle ear is present, this must be treated in the manner already described. Care should, however, be exercised, that the force employed during inflation be not greater than is absolutely necessary.

AUDITORY NERVE.—Of the syphilitic diseases of the auditory nerve, beyond the labyrinth, little or nothing is known. An intracranial disease involving some part of this nerve may be assumed, however, if in addition to the symptoms enumerated under the head of diseases of the labyrinth, positive symptoms of intracranial disease are present in a syphilitic individual. Foci of softening in the brain, gummata, circumscribed basilar meningitis or pachymeningitis, chronic periostitis ossificans of the petrous bone, with hyperostotic narrowing of the porus acusticus and paralysis of the trunks of the nerves from compression, are mentioned by Schwartze as the morbid conditions probably present in such cases. Of the morbid changes in the trunk of the auditory nerve and in its nuclei, due to syphilis, we have no knowledge.

B. INHERITED SYPHILIS.—Affections of the ear due to inherited syphilis are met with at two periods of life, during the first year and between the fifth and twenty-fifth years of age.

IN INFANTS.—In infants suffering from syphilitic disease of the nose and pharynx, affections of the middle ear are of common occurrence. Both the catarrhal and the purulent inflammations of this part, occurring under these circumstances, present no features by which they can be distinguished from the non-syphilitic form of inflammation. Caries and necrosis of the ossicles and the walls of the tympanic cavity may perhaps be developed more frequently, or more speedily, in the syphilitic than in the ordinary form, but no statistics are available by which this is proved. As in many of these cases the general health is seriously impaired by the constitutional disease, often but little attention is given to the ear affection by the parents or the medical attendant of the infant, and treatment is delayed until great destruction has already taken place. In a case of purulent inflammation of both middle ears, of two months' standing, which was recently under the care of the writer, paralysis of the right facial nerve existed when the patient was first seen, and paralysis of the left facial and exfoliation of the hammer and anvil of both ears occurred a few days later. The child was greatly emaciated, and although mercury was given at once and the usual local treatment pursued, the child died two weeks later, apparently from marasmus. The prognosis is probably less favorable in syphilitic cases than in otherwise healthy children, but under proper general and local treatment, begun shortly after the appearance of the disease, many cases make a good recovery. Concerning the pathological anatomy of diseases of the ear in syphilitic infants, we know but little. Baratoux (Transactions of International Medical Congress, held in Washington, D. C., September, 1887), who made autopsies of forty-three still-born or new-born infants with hereditary syphilis, found lesions of the middle ear twenty-three times, lesions of the labyrinth four times, and lesions of both parts twelve times. When the internal ear was affected simultaneously with the middle ear, without pus being formed in the labyrinth, the walls of the ampullæ and cochlea were reddened; the axis of the cochlea was injected and infiltrated with round cells, and the parts were bathed in a sero-sanguinolent fluid which had taken the place of the lymph. When the internal ear alone was affected, the blood-vessels were found dilated, the walls were thickened, and in some instances hemorrhagic spots were found.

The local treatment of these diseases does not require any other measures than those usually employed in the non-syphilitic form. Local treatment will, however, accomplish but little so long as the constitutional disease is active. For this mercury must be given; gr. x. of the mercurial ointment rubbed into the palms and soles twice daily, as recommended by Hutchinson, will usually make the symptoms disappear very rapidly. Iodide of potassium is rarely beneficial in these cases.

IN CHILDHOOD AND ADOLESCENCE.—*The Drum Membrane.*—Special affections of the external canal and drum membrane are doubtless of very rare occurrence in connection with syphilis hereditaria tarda. The only case of such a disease on record, so far as the writer knows, has been described by Pomeroy ("The Diagnosis and Treatment of Diseases of the Ear," 2d ed., p. 350) under the heading Papulo-tubercular Affection of the Drum Membrane in a Subject of Hereditary Syphilis. In this case, that of a boy, eighteen years of age, with parenchymatous keratitis and considerable impairment of hearing, both drum membranes, just behind and below the malleus handle, were the seat of a nodular, grayish mass of triangular form. Large blood-vessels traversed the region of the tumors. Efforts to remove the masses by wiping with cotton-wool were unsuccessful. After a few days the color of the tumors changed from gray to a dull red, and after the tumors had disappeared vessels of large size remained. Under constitutional treatment and inflation of the tympanic cavity the drum membrane regained its normal appearance in about six months. Pomeroy infers that the tumors were in the dermal layer of the drum membranes, as the malleus handles and short processes were distinctly behind the tumor. The drum membranes were not perforated. It is not denied that there was more extensive disease than this, there evidently being an inflammation of the drum cavity with exudation into the tympanal lining, including that covering the round and oval windows. The tuning-fork tests pointed to a suspicion of labyrinthine disease, but actual proof of that does not exist.

Middle and Inner Ear.—In the offspring of syphilitic parents, and almost exclusively in those of the female sex between five and twenty-five years of age, there occurs occasionally a disease of the ears producing in most cases great impairment of hearing or total deafness in a short space of time. The connection between the ear affection and inherited syphilis was first pointed out by Hutchinson,[62] though von Troeltsch and others had previously mentioned the occurrence of hardness of hearing in the children of syphilitic parents. Wilde's (*op. cit.*, p. 265) familiarity with the disease under consideration is shown by his remark: "It sometimes coexists with, sometimes alternating with, the ocular disease." "What is termed strumous ophthalmia, and also corneitis, are the forms which the eye affection assumes. Occasionally it is that of iridochoroiditis." Since the appearance of Hutchinson's paper numerous cases of this affection have been put on record by various authors, and the clinical history of the disease is now well known, but our knowledge of its pathology is still very meagre. This disease is by no means of as frequent occurrence as the eye affection of inherited syphilis, and is, as has already been observed, found chiefly in the female sex. The present writer has met with it (or rather has seen it associated with well-marked symptoms of inherited syphilis) but once in a male, while he has notes of over twenty cases occurring in females. Other physicians have had a similar experience. The disease seems to be, from all accounts, of less frequent occurrence in this country and in Germany than in England, where, according to Hinton, five per cent. of the aural patients treated at Guy's Hospital, London, suffered from it.

The subjects of this disease of the ears have, in many cases, manifested symptoms of hereditary syphilis during the first year of their lives, and usually have enjoyed good hearing during early childhood. The ear disease usually begins between the fifth and twenty-fifth years of age, and is commonly preceded by an attack of parenchymatous keratitis or of an inflammation of the uveal tract of one or both eyes. Not infrequently the ear disease commences while the eyes are still inflamed, and occasionally it precedes the eye disease. Painless swellings of the larger joints, more particularly of the knees, which pass away without much treatment, are often present at the same time, or are developed later on. In most of the cases, the patients or their guardians are unable to assign an immediate cause for the ear trouble; but occasionally, as in one of Gradenigo's cases,[63] and in one of the writer's cases, both of which occurred in young women, the deafness was attributed by the patients to exposure, particularly of the head, to draughts of cold air while the hair was wet. The first symptom to attract the attention of the patient, or of those who are with her, to the ear affection is a sudden and marked impairment of hearing. Pain in the ear is almost never complained of. Vertigo, unsteady and staggering gait, subjective noises, and headache accompany the hardness of hearing in most cases. In a number of cases seen by the writer, vertigo and headache preceded the impairment of hearing; while in others these symptoms developed afterward. Occasionally nausea, vomiting, and headache usher in the attack. The hardness of hearing, which at first perhaps may not be of the same degree in both ears, increases steadily, and often very rapidly, to total deafness. Sometimes total deafness is found to exist as early as the second or third day after the beginning of the attack, but more commonly a period of from six to ten weeks elapses before this stage is reached. Occasionally the progress is still slower, and is then usually characterized by marked variations sn the degree of deafness from day to day.

The vertigo and the staggering gait usually continue for months and then gradually pass away. The deafness, after it has once become total, nearly always remains so. In several of the cases seen by the writer a perforative purulent inflammation of the middle ear, of one or both sides, develops several years afterward.

In the beginning of the disease the patients can usually hear the tuning-fork (the writer uses tuning-forks which, when struck with moderate force, are heard for from thirty to forty seconds normally when vibrating in the air near the ear) longer and louder through the air than through the mastoid process. The tuning-fork C^4 (2,048 vibrations a second) is often not heard at all. In some cases bone conduction for tuning-forks of small size, of high and low pitch, is entirely abolished, while massive forks (for instance Politzer's C fork, described and illustrated in his "Lehrbuch," 2d ed., p. 117) are still heard through the mastoid. In cases of complete deafness of both ears, seen by the writer, he found that the tuning-forks C (1,285 v. s.), C^1 (2,565 v. s.), C^2 (5,215 v. s.) were heard both through the air and through the mastoid only when they were struck with great force, and louder and longer through the mastoid than through the air. None of these forks was heard from the vertex or when placed between the teeth, but the large C fork of Politzer (which is two or three times larger than the others mentioned) was heard from vertex and teeth. The tuning-fork C^4 was not heard at all. The shrill whistle of a distant factory was heard. Their own voices the patients could scarcely hear. In other cases of total or nearly total deafness of both ears, in which also only the large tuning-fork C was heard, the writer found sometimes a preponderance of bone conduction over aërial in one ear, while the other ear gave an opposite result. Gradenigo (*op. cit.*), who used tuning-forks of the same size and make as the writer, obtained similar results from his experiments. The examination of children with tuning-forks is, however, in most cases, very unsatisfactory in its results, as many of them are apathetic and indifferent, and can rarely be induced to produce, by singing, the tone of the fork, and one is, therefore, never certain whether they hear the fork or simply feel its vibrations.

The objective examination of the ear may reveal a perfectly normal condition of the drum membrane, the tympanic cavity, and the Eustachian tube, or evidence of present or past disease of these structures. Acute catarrh of the middle ear will be found present in an inconsiderable number of cases, and changes in the drum membrane, evidently the remains of bygone disease, in many others. Symmetrically placed areas of redness (localized periosteitis) on the posterior and upper wall, in close proximity to the drum membrane, in both external canals, were observed in a well-marked case of this disease by Buck (Transactions of American Otological Society, 1889, p. 62). Disease of the naso-pharynx is as often present as it is not. Perforating ulcers of the hard and soft palate, caries and necrosis of the naso-cranial bones, and ulceration of the larynx will be found in a small percentage of the cases.

The diagnosis of the peculiar ear affection under notice presents no difficulty if, in addition to the aural symptoms previously described, other symptoms of syphilis hereditaria tarda are present or have preceded the ear trouble. In addition to the eye diseases already mentioned, these patients often suffer from chronic inflammation of the knees or other large joints. The knees are often very much enlarged and locomotion may be painful, but there is rarely spontaneous pain. The disease usually passes off in the course of a few weeks, leaving the joints apparently in as good a condition as they were before the attack. Nodes on the long bones are also not infrequently present. With regard to the peculiarities of the teeth, Hutchinson says: "If the upper central incisors are dwarfed, too short, and too narrow, and if they display a central cleft in their free edge, then the diagnosis of syphilis is almost certain. If the cleft is present and the dwarfing absent, or if the peculiar form of dwarfing is present without any conspicuous cleft, the diagnosis may still be made with much confidence." Perforating ulcers of the hard and soft palates, deep ulcers of the pharynx, caries and necrosis of the naso-cranial bones, and laryngitis are less often seen than the other affections above mentioned. The patients, moreover, often have withered and old-man-like features, a peculiar square form of the forehead, prominent frontal eminences, a sunken nose, and scars about the angles of the mouth.

With regard to this disease Hinton [34] remarks that he knows of no other affection, except fever, which in a person under twenty years of age brings on a deafness so rapid and complete, and Hutchinson says that it may be broadly stated that if a child or young person, without either earache or otorrhœa, becomes quickly and completely deaf, the patient is almost certainly syphilitic. The writer has, however, recently met with two cases, both in vigorous boys, without the slightest sign of syphilis, in whom nearly total deafness was very rapidly developed while they were in excellent health. No disease of the middle ear could be discovered, and no febrile disturbance preceded or accompanied the onset of the deafness. Examination failed to reveal intracranial disease at the time, and none has developed since. The parents of these boys absolutely denied having had syphilis. Other otologists have doubtless met with similar cases, and have, like the writer, come to the conclusion that hereditary syphilis of the ear cannot be diagnosed from the symptoms presented by the ear affection alone.

From the ordinary catarrhal inflammation of the middle ear (from which syphilitic children are no more exempt than others) the disease here described can be readily distinguished by the clinical history and the results of the local treatment.

In the absence of post-mortem examinations of the organs of hearing of typical cases of this disease, the writers on this subject are divided in the opinion as to the seat of the lesion. Hutchinson thinks it tolerably certain that the internal ear or the nervous apparatus is the seat of the affection, but as to the exact site and the nature of the morbid process he is still in doubt, and most English writers are of the same opinion. Politzer and Schwartze do not hesitate to speak of the disease as inherited syphilis of the labyrinth, and Gradenigo calls it a syphilitic otitis interna. The view that both the conducting and the nervous apparatus are liable to be involved in this disease is held by Hinton and others, and Roosa has come to the conclusion that the disease is one chiefly of the peripheral and not of the central part of the organ of hearing. The view expressed by the writer in another place,[64] that disease of the nuclei of the auditory nerves might be the cause of the deafness, he has now abandoned, and a larger experience and further study of the disease leave but little doubt in his mind that the labyrinth is involved in all cases, and that in many, both it and the middle ear are the seat of the morbid process. The apparently normal state of the accessible parts of the middle ear found in acute cases, together with the total deafness for the voice with which the disease ends, must be regarded as strong evidence that the auditory nerve is the part affected, and the absence of other signs of cerebral disturbance makes it positively certain that its terminal apparatuses are chiefly affected. The results of tuning-fork tests cannot be utilized, as we have seen, in the settlement of the question as to the seat of the disease. That in many cases evidences of disease of the middle ear are not wanting is generally admitted, but they are rarely sufficiently marked to account for the profound deafness. The usual treatment for the middle-ear affection of children, moreover, is rarely followed by improvement in the hearing, even in the cases in which, under it, the objective signs of the disease disappear.

The purulent inflammation of the middle ear, with perforation of the drum membrane, which developed in several of the writer's cases years after the attack which destroyed the hearing, may have been due as well to a gradual increase in the inflammation of the lining membrane of the middle ear as to an extension of a purulent inflammation from the inner ear to the tympanic cavity.

Treatment is generally regarded as of no avail in any except very recent cases. Hutchinson thinks it more than justifiable, having regard to the terrible results in prospect, *in early* stages of ear disease of this type from inherited taint to confine the child to bed and induce ptyalism quickly. Knapp has reported a case in which a cure occurred under the use of mercury; but the writer, who adopted Hutchinson's advice in a number of cases, has been unable to arrest the progress of the disease in a single one. The iodide of potassium has been given in such cases by the writer for many years, and sometimes with apparent benefit, which, however, was generally transient. Buck saw marked improvement follow the administration of this remedy in gradually increasing doses (gr. v. to gr. xxxviij. three times a day). If middle-ear disease is present, it should be treated by inflation and other means, and even in cases presenting no marked evidence of a middle-ear affection it is best to give the patient the benefit of the doubt and treat him locally as well. Pritchard advises repeated blistering behind the ear for several months in all cases, and as it can do no harm it may be worth while to try it. Hinton has seen striking improvement follow in a severe case from scruple doses of hydrochlorate of ammonia, and has seen good effects produced by the injection of iodine vapor into the tympanum in less marked cases. Favorable hygienic surroundings and a sufficiency of good food are, of course, to be desired in the treatment of all cases of ear disease, but, if the writer may judge from his personal experience, they have little or no influence on the course of this disease. *Charles J. Kipp.*

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EAR DISEASES: TRAUMATIC AFFECTIONS.—For the sake of orderliness and convenience it is proposed to discuss the subject of injuries to the different parts of the organ of hearing under the following heads: Traumatism of the Auricle, Traumatism of the External Auditory Canal, Traumatic Perforations of the Membrana Tympani, Gunshot Wounds of the Ear, and Fractures at the Base of the Skull involving the Petrous Portion of the Temporal Bone.

Traumatism of the Auricle.—The exposed position of the auricle renders it particularly liable to various forms of injury. The importance of these injuries depends entirely upon the extent of the deformity. Superficial bruises and light forms of contusion generally fade away rapidly without leaving any disfigurement. Perichondritis, ulceration, or gangrene rarely follows the lighter injuries, but if the cartilage has been weakened by previous disease the tendency to ulceration is thereby much increased. Ulceration of the cartilage frequently results in auricular deformity. Fracture of the cartilage is not infrequently seen when the violence has been very severe. Incised wounds, even when there has been more or less loss of tissue, usually terminate favorably. Union occurs by first intention if the edges of the wound are brought together by interrupted sutures under strict antiseptic precautions. Piercing the lobe of the ear is a practice liable to cause violent inflammation, gangrene, and possibly tetanus. The dragging of heavy earrings is apt to produce a condition known as cleft ear, which is easily corrected by a plastic operation. Where the lobe is torn or cut, the edges of the wound should be brought together and sutured. The absolute loss of the auricle from any cause does not appear to affect the hearing power to any appreciable degree unless, as a result of replacing the severed member, atresia of the auditory canal develops during the process of healing. Should replacement be impossible, an auricle made of papier-maché will be found a very serviceable substitute.

Traumatic hæmatoma auris, or othæmatoma, is caused by the severer forms of injury and is more frequently seen on the left auricle than on the right, seldom on both. It is characterized in most cases by an effusion of blood between the perichondrium and cartilage, but should the violence be slight the effusion may be limited to the layers of the cartilage, or it may be simply subcutaneous. The tumor is a circumscribed swelling of a bluish-red color and appears most frequently in the fossæ triangularis and scaphoidea. It is rarely fluctuating and is hard or soft to the touch. Considerable pain and a feeling of fulness and heat are usually experienced during its development. The entire auricle is but seldom involved. Perfect absorption of the sanguinolent fluid will insure a normal restitution of the part, but imperfect absorption will, on the other hand, lead to organization of the fluid with cicatricial thickening, contraction, and atrophy, producing a shrivelled mass so well known to pugilists—the shrunken or cauliflower ear. The lighter forms of traumatism of the auricle rarely require any treatment. In hæmatoma the treatment should be expectant, and if the tumor is painless it is better not to interfere at all. Massage and fomentations tend to increase the effusion rather than favor its absorption. Evacuation of the swelling by aspiration is advised only when positive signs of pus are present, or after local treatment fails to relieve the pain. The application of ice, or ice water by means of the Leiter coil, or the use of Goulard's solution tends to reduce the violence of the inflammation and pain. Incision and packing the cavity with gauze are to be resorted to only when other means fail to effect a cure.

As a result of personal encounters, the practice of biting the auricle is not infrequently seen in foreign countries and among our foreign population. Various degrees of mutilation, from incised wounds to total amputation, have been reported. The danger of such wounds lies principally in ulceration of the cartilage and in the development of general toxæmic symptoms.

Traumatism of the Auditory Canal.—Traumatism of the auditory canal is more frequently seen in the osseous portion and is commonly due to rough and over-zealous efforts made in extracting foreign bodies, or to the use of hairpins, knitting needles, and the like, for the relief of itching. Injuries of the cartilaginous canal almost always represent an extension of traumatism of the auricle. Fractures are generally due to indirect forms of violence, and are further complicated in many cases by fractures of the base of the skull. A blow or fall on the point of the chin may fracture one or both osseous canals, and such a fracture may or may not involve the osseous walls of the tympanum. Rupture of the membrana tympani, while nearly always present, is not a constant factor. The swelling and laceration of the membranous canal make it very difficult to verify the presence of a perforated drum membrane. Bleeding from the canal is always present, and when the soft parts have been badly torn the hemorrhage is considerable; but its profuseness by no means proves the existence of a fractured base. The escape of a watery fluid from the injured ear is commonly considered to be a reliable sign of such a fracture. Facial paralysis usually complicates the severe cases, and occasionally loss of taste is observed, from involvement of the chorda tympani nerve. The subjective symptoms in the light forms of trauma are transient. Deafness and constant tinnitus aurium are liable to become permanent if the labyrinth is in any way involved. Deformities resulting from slight injuries are rarely observed; but an extensive fracture of the osseous walls may result in caries, in the formation of sequestra, and ultimately in stenosis or complete atresia. The complicated forms of trauma often end fatally in meningitis, although a number of seemingly hopeless cases have terminated in recovery.

The treatment of all forms of trauma should depend upon the changes noted in the tissues. Douching with hot boric-acid solution, four per cent., or with 1 to 5,000 bichloride solution, is usually practised, and is particularly indicated when there is evidence of suppuration. For the relief of active inflammation of the soft parts antiphlogistic measures are of benefit. The progress of repair in extensive fractures is most tedious, since in such cases the removal of sequestra, cauterization of granulations, and obliteration of fistulous openings may be necessary. The pronounced inflammatory reaction following severe injuries is not confined to the auditory canal only, but is often located within the middle ear as well, thereby adding other important considerations in the question of treatment.

In considering the lesions of the auricle and auditory canal from a medico-legal standpoint, it is most difficult to formulate any rules upon which a surgeon can base an opinion, as it is most exceptional ever to see two cases alike. In estimating the extent of an injury to the auricle it is essential to exclude any previous disease or weakness of the cartilage, since a deformity out of all proportion to the force of the violence may result in such cases. One should be guided by the form of the violence, the extent of the injury, and the final result. Serious injuries are those which result in disfigurement; an injury may be termed slight when no change in the form of the auricle takes place.

Traumatic Perforations of the Membrana Tympani.—Traumatic perforations of the membrana tympani are the result of direct or indirect forms of violence. The direct forms are most frequently due to efforts made in extracting wax, or to the use of knitting needles, hairpins and the like, to ease itching of the canal. The instrument in such cases is inserted too far, or by an accidental push of the arm it is driven down through the drum membrane. Careless use of the probe without sufficient illumination, lack of skill on the part of the surgeon in removing foreign bodies, reckless use of ear syringes, particularly those with long, pointed tips, too violent syringing, introducing Eustachian-tube bougies too far, are among the occasionally observed causes of direct rupture. Indirect ruptures are due to sudden condensation or rarefaction of air in the external canal, as in detonation of heavy ordnance, in explosions, in violent coughing or sneezing—in which acts the intratympanic pressure is increased,—in abuse of pneumatic massage, and in concussion of the head; they may also be caused by extension of fractures at the base of the cranium. Fracture and dislocation of the ossicles can occur quite as readily through the entrance of a foreign body (direct) as by extension of cranial injury (indirect). The seat of fracture is usually in the lower portion of the manubrium, and is recognized by the obtuse angle formed by the broken portion with the upper end.

The symptoms following the various kinds of traumatic injuries to the drum membrane are often so severe that the patient is incapacitated for any work. The instant the perforation occurs there is a loud report in the affected ear, followed by pain, tinnitus aurium, and more or less deafness. Vertigo, nausea, and vomiting are more frequently present when simple concussion of the labyrinth exists. Bleeding from the ear is generally slight in uncomplicated cases; but profuse and prolonged hemorrhage indicates deeper and more extensive involvement. Suppuration of the middle ear is not so apt to follow the indirect as the direct forms of rupture, but its development will retard the recovery in either form. In mild cases of trauma the deafness rapidly disappears, but should suppuration of the middle ear follow the traumatism and produce permanent changes within that cavity, or should the labyrinth be injured, such conditions are liable seriously to affect the hearing power. Simple, uncomplicated traumatic rupture of the drum membrane heals in a very short time, the site of the perforation being finally indistinguishable from the uninjured portion. Some importance is attached to traumatic perforations on account of the exposure of the middle-ear cavity and the subsequent inflammatory process that is liable to follow such injuries. When the drum membrane has become resistant through the presence of interstitial catarrhal changes, calcification, etc., traumatic perforations rarely occur, so that the full force of the violence is transmitted through the ossicular chain to the labyrinth and terminal filaments of the auditory nerve. The objective changes noted in such cases are injection of the vessels, ecchymoses, and hyperæmia. Extreme and occasionally absolute deafness and distressing tinnitus aurium are almost always the results. Again, when the drum membrane has been weakened by previous disease, as atrophy, cicatrices, etc., traumatic perforations readily follow the lightest forms of injury, causing little or no damage to the hearing power, provided no subsequent complications develop. Traumatic perforations can be single or multiple. The form following any direct violence depends upon the size and shape of the instrument used to produce them. They are usually seen in the anterior or posterior inferior quadrant; still any portion of the membrane is quite as liable to be injured. Indirect ruptures are most frequently seen behind or in front of the manubrium, and are oval or elliptical in shape, seldom round. The long axis of the rupture is parallel with the direction of the radiating fibres, and the edges are partially or totally covered with blood. Ecchymoses in the drum membrane and injection of the vessels along the malleus and over Shrapnell's membrane are often present. In treating cases of traumatic rupture it is best to avoid all forms of medication, and simply to protect the delicate middle ear from sudden atmospheric changes by the introduction of a piece of cotton into the external canal. The development of suppuration in the tympanum should be handled by the recognized rules governing that disease. Marked tinnitus aurium and deafness due to labyrinthine involvement are often relieved by the application of the galvanic current.

An action for damages in a court of law for simple, uncomplicated perforation of the drum membrane is of less frequent occurrence than formerly, when the popular fallacy of absolute deafness following such injuries received more or less credence. When a medico-legal opinion is required, it is quite essential that the case be examined within two or three days after the injury has been received. Should the characteristic appearances of a traumatic perforation be present, its nature can be further verified by observing the progress of cicatrization from day to day; this plan will enable the examiner to discriminate between it and the presence of a perforation due to prior pathological processes. If too long a time elapses between the date of the injury and the examination, complete cicatrization may obliterate all traces of the perforation, and any existing functional complications could not then be associated with the cause. If, at the time of the examination, suppuration has already developed, it will be impossible to differentiate the condition from the appearances seen in primary forms of purulent inflammation. Audition is only in rare cases permanently involved by uncomplicated traumatic perforation. The hearing power generally returns to its former degree of acuteness on the completion of cicatrization. As the amount of damages depends upon the degree of permanent disability incurred, such injuries are considered transient

Serious injuries of the drum membrane are those which are complicated with concussion of the labyrinth, and in which the subsequent development of purulent inflammation of the middle ear produces deafness through the pathological changes following that disease. Yet deafness due to concussion of the labyrinth has been known to disappear in from four to six months' time, and severe purulent inflammation has subsided without leaving any unfavorable results to the hearing power. When deafness and distressing tinnitus aurium follow a blow unaccompanied by the occurrence of a perforation of the membrana tympani, it is very difficult to determine, in the absence of any reliable data, whether the condition present was produced by the trauma, or was caused by the existence of previous chronic pathological changes in the tympanum and labyrinth. In any given case it is wiser to reserve judgment until satisfactory and conclusive evidence is secured through prolonged and careful observation.

Gunshot Wounds of the Ear.—Gunshot wounds of the *auricle,* although rare, may cause considerable loss of tissue and much deformity; but any extensive loss of substance is seldom unassociated with involvement of the adjacent structures. Small bird shot are occasionally found embedded beneath the auricular epidermis as a consequence of accidents attending hunting parties. No deformity is produced thereby and no difficulty attends their successful removal. On account of the complicated structure of the auricle, all attempts to correct deformities following much loss of tissue by plastic surgery have been rather unsatisfactory. Small defects of the upper border and lobule have been successfully replaced by flaps, but new auricles made in a similar manner are without character or formation, and give far less satisfaction from a cosmetic point of view than the artificial ones.

Gunshot wounds of the *external auditory canal* are nearly always associated with cranial injury. The close relationship between the auditory canal and the temporal bone renders it impossible to injure the one without injuring the other. A spent bullet may strike the auricle or auditory canal without causing any laceration, although a deep, painful bruise and absolute deafness result. A bullet striking the head in the immediate neighborhood of the ear usually enters the middle cranial fossa, causing extensive fracture of the pyramid, and injury to the jugular bulb or vein, to the carotid artery, and to the brain and its membranes. Such cases are necessarily fatal. Suicidal attempts made by shooting in the auditory canal are by far the most frequent class of cases seen. Vast damage may be the result therefrom, or, as has been reported, the bullet may reach the pars petrosa and lodge there without causing any injury to the meninges or brain, and upon its removal recovery will take place, but the hearing power will, as a rule, be completely destroyed. In some other cases of a similar nature the reports state that the pistol was placed in the auditory meatus and pointed backward, and the ball, after shattering the osseous wall, became lodged in the substance of the mastoid bone, from which it was subsequently removed without fatal results. From these reports it would appear that shooting into the ear is not necessarily fatal. Gunshot wounds of the ear complicated by injury to the meninges and brain are of secondary importance as compared with that of the cerebral lesion, and it is therefore rare that an otologist ever has an opportunity to see such injuries in their early stages. It is only after recovery from the head injury that the patient seeks the aid of an ear specialist to restore the hearing power or to check the purulent discharge. In such cases, as has been reported, it is not uncommon to find the pistol ball lodged in some portion of the osseous canal, a fact which an early examination would have ascertained; and in consequence of this discovery the ball would have been promptly removed and the serious aspects of the situation would have been diminished. Wounds in and about the ear should suggest the most careful and painstaking investigation.

Treatment.—The utmost care must be exercised in endeavoring to locate the bullet, and if it is found, every effort should be made to extract it, particularly if threatening symptoms are present. The Roentgen rays may prove to be of inestimable value in detecting the location of the bullet, and in determining whether or not it might be successfully extracted. Whatever operation may be determined upon should be guarded by every observance of modern antiseptic surgery. Much destruction of tissue and shattering of bone may render any required operation very difficult through the obliteration of well-known surgical landmarks.

Fractures of the Temporal Bone.—In describing fractures at the base of the skull, it is the intention to limit this article to that portion of the subject which relates more especially to the domain of otology and which usually meets with brief mention at the hands of the general surgeon. Cases of this class involving the temporal bone rarely come under the immediate care of the aural surgeon, and in consequence a careful examination of the auditory canal and membrana tympani with reflected light and aural speculum is seldom thought of or considered necessary. In view of the brilliant advance of modern surgery and its achievements in special or regional work, it is to be regretted that the opportunity offered by such an examination to learn of the condition of the temporal bone in relation to a fractured base, and the invaluable aid such information would give in shaping the course of the treatment, have been so wantonly neglected.

It may be asserted in a general way that fractures of the base of the skull always involve the temporal bone to a greater or less degree, but the wisdom of dividing them into the two following classes has often been verified by clinical observation:

1. A fracture or fissure of the tympanic or squamous portions without causing any corresponding damage to the petrous portion.
2. A fracture of the tympanic portion and pars petrosa occurring simultaneously.

The line of fracture or fissure in the first division is found to extend along the line of union of the squamous, the tympanic, and the petrous portions, which represent in the fœtus three centres of ossification. The line of fracture in the second class passes through the body or substance of the petrous portion. Whether a fracture of the petrous portion of the temporal bone may occur without involving the tympanic or squamous divisions is a possibility not yet fully established by clinical data.

Fractures such as we are now considering are always caused by the indirect forms of violence, styled by the French observers "contrecoup" (counter-stroke), and are usually seen as a result of a fall, the patient striking the top or base of the skull. The peculiar construction of the temporal bone renders it liable to such forms of injury, as its resisting power is much reduced by the presence of several cavities within its substance—cavities which are separated only by very thin osseous walls. Force applied to the vertex expends itself on some distant point through elasticity of the cranium, and, owing to its weakness, the temporal bone is almost always damaged. The external auditory canal in the region of the fissura Glaseri is that portion of the temporal bone which is most frequently involved, yet the locality of the fracture depends on the site of the traumatism. If the violence is applied in the region of the occiput, fracture of the posterior osseous wall results, and this may or may not involve the mastoid; a severe blow or fall on the point of the chin may cause a fissure or comminuted fracture of one or both anterior walls. As a rule, however, fractures are rarely seen limited entirely to the auditory canal, for in most cases in which the traumatism has been severe, it is further complicated by a contemporaneous fracture of the superior or inner walls of the tympanum, and at times of the pyramid. Fracture of the walls of the tympanum may involve the facial canal in some portion of its course, producing a paralysis corresponding to the particular locality injured. There is always a laceration of the mucous membrane lining the cavity of the tympanum, corresponding to the line of fracture. Fracture of the ossicles or dislocations of their articulations or detachment of the drum membrane from its groove are seen only as a result of excessively violent traumatism. The membrana tympani, while not always involved, is ruptured most frequently in the neighborhood of Shrapnell's membrane. The perforation appears in the form of a linear or oblong slit traceable along the superior or anterior meatus. Multiple perforations of the drum membrane are most rarely observed. Concussion of the skull occasionally produces a hemorrhagic extravasation in the tympanum, causing a condition known as hæmotympanum. The drum membrane appears to bulge and is of a dark-blue color; sudden deafness, tinnitus aurium, pain, vertigo, and a feeling of fulness in the ear result, but upon absorption of the extravasation these subjective symptoms disappear. When the line of fracture passes through the petrous portion of the temporal bone, involving the internal auditory canal and the nerve trunks passing through it and lacerating the delicate membranous labyrinth, deafness is immediate and absolute, and it is observed as soon as the patient recovers consciousness. Damage to the nerves in the internal auditory canal is seldom if ever confined to the acoustic; the facial nerve is injured at the same time. A staggering gait, vertigo, nausea, vomiting, and facial paralysis generally persist for months, and in some cases these symptoms remain unchanged for years. Such functional disturbances are not always due to a fracture, however, but are seen as a result of pressure following an extravasation of blood. Injuries to the osseous portion of the Eustachian tube and the mastoid cells are rare, but the extension of the line of fracture to the nose through the anterior fossa and ethmoidal cells is more frequently observed. Paralyses of special nerves appearing immediately after the injury are due to laceration or compression; those seen to occur some time after the injury may be due to inflammatory action. Among the symptoms connected with fractures or diastases of the temporal bone, associated or not with a contemporaneous fracture of the base, and to which considerable importance has been attached, are: hemorrhage and an escape of a watery fluid from the injured ear. Profuse bleeding from the auditory canal, with a discharge of a watery fluid, can occur only when some portion of the membrana tympani is perforated or when the line of fracture and laceration of the soft parts extends well into the external auditory canal. Bleeding from the ear under these circumstances, even though it persists a comparatively long time, has not that critical significance which has heretofore been attributed to it. It does not necessarily indicate that the tympanum and one or more of the large vascular channels surrounding it have been opened, for the region in which these lacerations most frequently occur—the membrane of Shrapnell and the superior wall of the auditory canal—is sufficiently rich in blood-vessels to account for it. Alarming hemorrhage from the ear has been known to follow injury limited to the osseous canal; it has also been observed in cases in which a rupture of the drum membrane and a laceration of the mucous membrane of the middle ear have occurred without any demonstrable evidence of the existence of a fractured base. As a symptom, therefore, bleeding from the ear means a rupture of the soft parts in the vicinity of the line of fracture, since authentic cases of fracture of the temporal bone have occurred without the slightest hemorrhage or bleeding from the ear. The escape of watery fluid from the ear is a symptom of graver import, and is generally considered to point to a fracture of some part of the petrous portion of the temporal bone, with a tearing of the cerebral membranes. When first seen its color is a reddish-white, but later it becomes clear as water, and is considered to be cerebro-spinal fluid. Every watery or serous discharge from the ear is not necessarily cerebro-spinal fluid, for this symptom occurs in acute inflammation of the middle ear of non-traumatic origin. The presence of this watery discharge from the ear in no way implies a fatal issue, as such patients have recovered, but the symptom aids in forming an estimate of the extent of the injury sustained by the temporal bone.

Diagnosis.—In trying to discover the extent of a fracture of the temporal bone in a general way, the use of the tuning-forks renders much valuable information. In fractures of the first class, a tuning-fork placed on the vertex will be heard better in the affected ear; in those of the second class, in which the fracture includes the pars petrosa, the tuning-fork will be perceived more distinctly in the unaffected ear. A complete or partial restoration of the hearing power may be looked for in the first class of cases; in the second, permanent deafness follows. Deafness following contusion of the head without symptoms of basal fracture is usually incomplete, and is generally first noticed some days after the injury. It may be caused by inflammatory neuritis, by hemorrhagic inflammation of the labyrinth, or by involvement of the acoustic centre.

Treatment.—In treating fractures of the temporal bone more attention should be devoted to learning the extent of damage sustained by the osseous canal, drum membrane, and middle ear, with the view of preventing any extension of the inflammation resulting therefrom to the adjacent structures. Acute inflammation of the tympanum follows these injuries, and when the cavity of the cranium and the delicate meninges are exposed through the line of fracture, thereby opening up paths of infection for countless numbers of micro-organisms, much might be done to reduce the development of meningitis. Both the external auditory canal and the membrana tympani should be thoroughly inspected to establish the presence of a fracture or a rupture. Copious hemorrhage might make this difficult of accomplishment, but still it can be done. The treatment usually employed in acute inflammation of the middle ear can be used with benefit in the inflammation arising from a traumatism. When the details cannot be carried out, a thorough drainage and cleansing of the middle-ear cavity through the mastoid is a surgical possibility not to be forgotten. To prevent the development of meningitis should be the effort of the surgeon, but the application of the ice cap and rest in bed will not suffice when the channel of infection is left totally neglected to the invasion of what too often proves to be the exciting cause. *James B. Clemens.*

EAR DISEASES: TUBERCULOSIS OF THE MIDDLE EAR.—The occurrence of a purulent discharge from the ear in the latter days of patients afflicted with phthisis pulmonum was observed by the earliest clinical writers, who attributed it to poison within, seeking its way out. Naturally, nothing very precise was written on the subject until the use of the head mirror, which afforded a more exact way of observing the conditions occurring in various diseases, had been discovered. After this discovery had been made, certain peculiarities of the objective appearances in ear tuberculosis were soon chronicled.

As in most other pioneer otological work, so here also we find evidences of the fact that Politzer contributed his share. In his "Beleuchtungsbilder," published in 1865, he pictures one of the typical appearances of this condition. He was one of the earliest observers to write at all extensively on the subject, and gave one of the first satisfactory descriptions of the microscopic changes taking place in the mucous membrane of the middle ear in this disease. Still later, when tubercle bacilli were discovered, we find him one of the first to work out the presence of these in the discharge and in the ulcerated membranes.

During this interval many other observers worked upon the subject from various standpoints until to-day we find tuberculosis of the middle ear thoroughly well recognized, exhaustively studied, and in general as well understood as tuberculosis of any other organ or portion of the body.

Etiology and Pathology.—Theoretically, there is no reason why a tuberculosis cannot begin primarily in the ear, but, owing to the fact that the middle ear is shut off from the rest of the body, and communicates only indirectly with the lymphatic system—the great disseminator of tuberculosis, and also in view of the fact that the only direct connection which it possesses with the outside world is through a very narrow tube which passes down into the nose, we have a right to assume that it can only rarely serve as the primary source of a general tuberculosis. Cases have been reported in which the discharging ear furnished the first objective symptom, while only later, sometimes after a considerable lapse of time, did the lung and other symptoms manifest themselves. I have myself, however, never seen any cases in which I could satisfy myself that I had before me a genuine instance of primary middle-ear tuberculosis. There is one fact, however, which is indisputable, viz., that in the vast majority of cases the ear tuberculosis manifests itself long after the disease has been more or less active in some other part of the body.

How often aural complications occur in tuberculous subjects, it is not possible to state in exact statistics, all of the latter being more or less modified by the fact that the ear trouble is often so little noticed by the patient (and even less so by his medical attendant) that a great many patients even in our best-managed institutions die without any mention being made on the record of any discharge from the ear. In private practice a still larger number of cases remain undiscovered, or, if mentioned, are soon forgotten as being, in the presence of disease elsewhere in the body, unimportant. For these reasons I am disposed to believe that tuberculosis affects the middle ear much more often than is generally supposed.

It is probable that tuberculosis in the middle ear develops in one of two ways: either the tubercle bacilli effect a lodgment in the relatively healthy but constitutionally vulnerable tissues of the membrana tympani and middle-ear mucous membrane, or else they are favored, in making a successful invasion of the ear, by the fact that these parts are weakened by disease (infection by streptococci, pneumococci, etc.). The mode of approach of the bacilli, which doubtless are in the air a large part of the time, is clearly by way of the Eustachian tube.

It is interesting to note, in this connection, that oftentimes the most careful and persistent search (microscopical and bacteriological) fails to discover the existence of tubercle bacilli in either the discharge or the affected tissues themselves, and that too in cases which present the strongest possible clinical evidences of the existence of a tuberculous process in the middle ear. This experience has happened to the author in a number of instances.

It seems natural to inquire next as to the nature of the pathological processes which take place in the ear; how they progress step by step. The inflammation is almost always of the sluggish, asthenic type. Without much disturbance a discharge appears, and then, shortly afterward, a large part of the drum membrane will frequently disappear. Thus, sometimes, in the course of only a few hours, a whole quadrant will as it were melt away, or two independent perforations will form, will persist for a short time, and will then merge into one large defect. After this first loss of substance has taken place, frequently nothing further transpires beyond the simple conversion of the mucous membrane on the promontory wall of the middle ear into a granulating mass, and from this and the whole cavity of the middle ear there is secreted a thin acrid pus which, often in no very large amount, runs on for months and months until the demise of the patient. No very great further destruction of tissue takes place, and the granulating surfaces do not ulcerate, but most obstinately persist in giving forth the discharge.

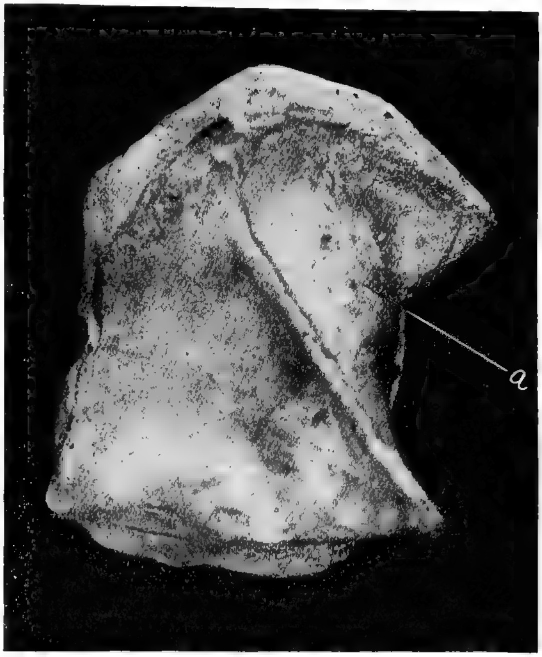

Fig. 1804.—Cast of Petrous Portion of the Temporal Bone, from a case of advanced tuberculosis of this part of the skull. (Original.) *a*, Roof of the tympanum, which is seen to be arched up into the middle fossa of the skull. The overlying brain substance at this point showed a corresponding depression.

In another group of cases the tuberculous process shows a most decided destructive tendency. Possibly this may be due in some measure to the fact that the patient lives longer, more time being thus afforded for the destructive processes to work. It is more probable, however, that there are real differences in the types of the disease itself. The drum membrane undergoes complete destruction. The ossicles become loosened and disappear in the discharge, and later we are able to discover that the bone on the promontory wall is bare underneath the granulating tissues which cover it. The process indeed does not even stop here, that is, with the formation of a limited area of bone caries; but, instead, quite large masses of bone tissue die. Especially is this liable to be the case in children in whom there is a well-developed general tuberculosis. The sequestra thus formed are sometimes of extraordinary size, including wellnigh the whole petrous portion of the temporal bone as well as the wall of the external auditory canal. Such pieces are only rarely extruded by natural processes; usually operative measures are needed for their removal. The periosteum or dural surface, in the specimen pictured in the accompanying cuts, presented an entirely healthy appearance except at the spot where the bone has been sawed in two, as is shown in Fig. 1805. At this spot the periosteum was very much thickened and consequently must have served as a barrier to the invading forces trying to enter the skull from the middle ear. The bone was entirely gone in places, but the thickened subperiosteal tissues were good for a long resistance, and the meninges of the brain were perfectly healthy, although there was at one point—corresponding to the projection shown on the temporal bone—a depression which extended into the brain substance and into which the ball of the thumb could be easily inserted.

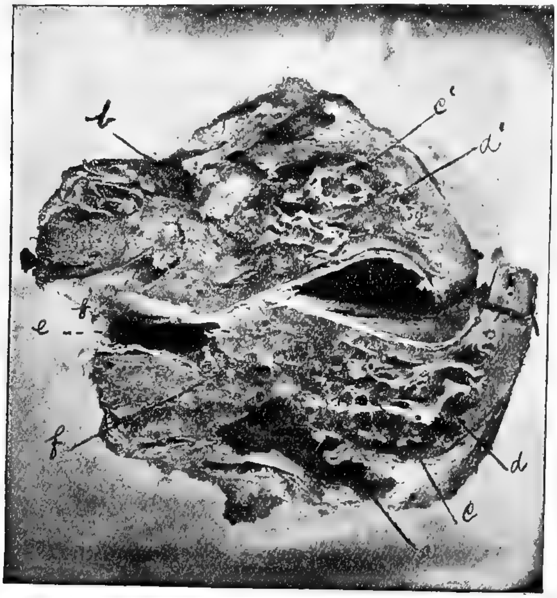

FIG. 1805.—Temporal Bone from the Same Case as that shown in Fig. 1804. The section (made with a saw) passes horizontally through the external auditory canal. Slightly reduced. (Original.) *a*, The floor of the external auditory canal and lower half of the middle ear; *b*, the upper wall of the canal, while the upper half of the middle ear is filled by a caseous mass. *c*, *c'*, section of a sequestrum or of a portion of the bone which is in a condition of osteoporosis (the extent of the same may be readily distinguished); *d*, *d'*, intact outer table of the skull; *e*, locality of the cochlea which had been involved in the necrosis of the neighboring bone structures; *f*, *f'*, caseous mass in the internal auditory canal.

Fig. 1805 shows also the marked osteoporosis, *c* and *c'*, involving a large mass which includes the internal ear, *e*, and the auditory and facial nerves, *f* and *f'*, especially the former, which had been reduced to almost a pultaceous mass. Although death in this particular case was from pure asthenia, it could not have been long delayed, as a septic meningitis was imminent owing to the broken-down condition of the nerve tissues, as mentioned above. Such a meningitis occurred in another case the temporal bone of which I had the opportunity thoroughly to study. In this case I removed a specimen from a part where the roof of the tympanum was very thin, decalcified it, and cut it into sections. Except in those portions of sections where there were cheesy masses, I was disappointed in not finding by the microscope anything that was materially different from what we find in cases of rarefying osteitis, whether tuberculous or otherwise in its origin. In the deeper layers of the periosteum there was a certain amount of inflammatory tissue, and this was found to extend into the Howship's lacunæ and Haversian canals, arranging itself in layers and tiers of cells close to the bone proper. As will be seen from Fig. 1806, the osteoclasts seemed to sink themselves into the bone substance exactly as in other forms of bone decay. The impression which I gathered from studying these sections was that the only difference between the conditions here and those which are observed in simple rarefying osteitis, is this: the osteoclasts in the tuberculous form are perhaps a trifle larger than they are in the simple variety. In this case the tubercle bacilli were found back in the caseous tissue, where the coagulation necrosis was taking place, but were not discovered in the actually inflamed area where we assume that phagocytosis is most active, the latter being nature's attempt to throw a barrier around the diseased tissue for the purpose of separating it from the healthy.

In the milder cases we have in the mucous membrane of the middle ear, as occurs in the larynx, ulceration and the formation of granulation tissue; these alterations, which are caused by other micro-organisms than the tubercle bacilli, frequently yield readily to treatment. The other deeper lesions of the mucous membrane are found to have the giant cells and the coagulation necrosis as well as the tubercle bacilli.

This leads me to repeat the statement which I made in the earlier part of the article, viz., that the beginning of the trouble in the ear in many cases is probably simply a streptococcus or pneumococcus infection, and that it is only later that the tubercle bacilli get a chance to work out their full measure of mischief, the tissues being prepared for the latter by the previous inflammatory conditions

SYMPTOMATOLOGY.—When a tuberculous patient comes to consult the aural surgeon for relief of his ear trouble he relates that he had a feeling of fulness and discomfort in his ear for perhaps only a few hours or for a number of days, but that his attention was only seriously directed to his ear when, on arising some morning, he discovered that his ear had been discharging as shown by the presence of dried matter on the outside of his ear or by the staining of his pillow. He will relate, further, that since this particular occasion he had experienced no trouble beyond the fact that the discharge and the deafness had both continued to exist. The latter symptom is frequently much less marked than that which would accompany any other purulent otitis media. So significant is this quiet beginning of the disease that whenever a patient comes complaining of painless discharge and persistent though not severe deafness, I am at once suspicious that the underlying cause is a tuberculosis of the middle ear.

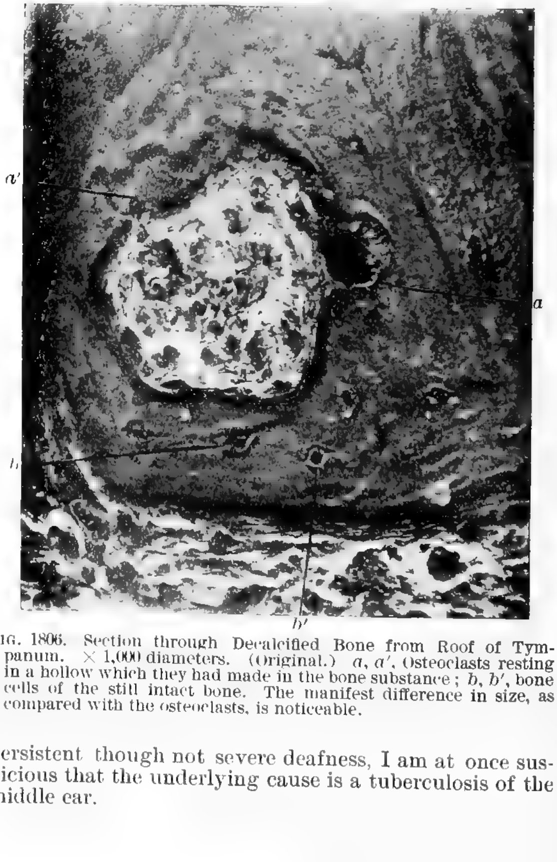

FIG. 1806. Section through Decalcified Bone from Roof of Tympanum. × 1,000 diameters. (Original.) *a*, *a'*, Osteoclasts resting in a hollow which they had made in the bone substance; *b*, *b'*, bone cells of the still intact bone. The manifest difference in size, as compared with the osteoclasts, is noticeable.

If an examination is made early in the progress of the trouble, one often finds more than one perforation. Quite frequently I have seen these double perforations, but in no instance have I seen more than two. Troeltsch, however, records having seen on one occasion three. Multiple perforations are considered a sure presumptive sign of tuberculosis, and my own experience would lead me to place as high a value upon this piece of evidence as I would upon the presence of a pyriform swelling of the arytenoid cartilages of the larynx, or upon that of a dull apex of the lungs. These independent perforations persist for a shorter or a longer time and then merge into one large defect.

In carrying out the treatment of one of these cases of tuberculous disease of the middle ear the surgeon secures ample opportunities for observing closely the progress of events. Thus, for example, he will notice, in the milder cases, that after a certain period there ceases to be any further erosion of the drum membrane; the ulcerated edge retracts, folds backward, and is usually more or less overlapped by the granulation tissue which springs up from the promontory wall. Then, in a certain proportion of the cases, even when all local treatment is completely abandoned, the further formation of granulation tissue or of polypi ceases; in fact, such granulations may gradually shrivel up and the discharge become very scanty. Such partial spontaneous cures are not very uncommon. They remain in this state of comparative quiescence for varying periods of time; the patient finally dying without anything new of any importance having transpired in the middle ear.

In other cases the disease, from the start to the finish, pursues a very different course. In these cases, which belong to a more virulent type, and in which, after the destruction of the membrana tympani, the malleus and incus are exfoliated and washed out with the discharge at a comparatively early stage, the patients frequently complain that the ear is more or less painful and that there is a deep-seated boring; the discharge also becomes very foul-smelling, traces of blood are seen, and if one carefully cleanses such an ear and uses his probe with discretion he will easily discover that it passes through or between the portions of the granulating tissue and encounters bare bone. This bare bone sometimes is merely a simple caries of the bony wall of the middle ear and may be found in any portion of it, more frequently on the promontory wall,—perhaps because it is more accessible,—but it also occurs, as the probe will often discover, on the annulus tympanicus, on the roof of the tympanum, toward the mastoid, and even in the external canal itself. At a still later stage, in these progressive cases, it becomes evident to the medical attendant that he has to do with conditions of the ear such as are pictured in Figs. 1805 and 1806, *i.e.*, with the formation of large necrotic masses and of sequestra. In children this will frequently progress in such a way that a little manipulation with the instruments or a little direct operative interference will disclose the fact that the masses are no longer attached to the healthy bone and consequently that they can be removed. Almost every aurist who has had more than a limited experience can recall cases in which larger or smaller masses have thus been removed either through the natural canal or by the various methods of laying open the ear from behind.

Occasionally, however, it transpires, as in the case from which the specimens which illustrate this article were taken, that the mass does not separate, does not give any evidence of loosening, and is so extensive as to deter one from even advising—in the weak condition in which these patients find themselves—any operative interference. In cases of this kind the infection which induces the terminal meningitis reaches the cranial cavity either by way of the roof of the tympanum, which breaks down and disappears, or by way of the labyrinth and internal auditory canal, after the destruction of the soft parts. The resulting meningitis in these cases is usually of the asthenic type. Gradually the patient succumbs to the slowly oncoming coma. He may have short attacks of dizziness and headaches from which he seems to recover entirely, later, however, he generally sinks into the comatose condition as into a sleep, and never regains consciousness. It very rarely happens that a patient, in a case of this kind, develops a brain abscess or any other intracranial affection than the basilar meningitis which produces the fatal termination. In the simpler cases, on the other hand, one rarely has to do, from first to last, with any pain or inconvenience, such as are quite commonly experienced by the patients belonging to the class just described.

PROGNOSIS.—As already stated in an earlier part of this article, it is sometimes a very difficult matter, or even impossible, to prove, in any given case of extensive necrosis of the temporal bone, that we are dealing with tuberculous disease. Furthermore, the formation of these large sequestra in the temporal bone has been known to follow a severe attack of scarlet fever, without the interposition, so far as could be judged, of tubercle bacilli. Consequently, when one of these large masses is cast off spontaneously, or is removed by operative interference, and the patient gets entirely well again, it is hard to maintain, with any degree of confidence, that the case in hand was a genuine instance of recovery from extensive bone disease due to tuberculosis of the middle ear. I have myself observed only one case in which I felt confident that my patient had really recovered from an extensive tuberculous necrosis of the temporal bone. Under these circumstances, therefore, I am scarcely warranted in saying very much about the prognosis of the disease. That it is very grave, but not absolutely unfavorable, is all that the facts permit.

DIAGNOSIS.—So much has already been said in various parts of the present article (in relation to the diagnosis) that it will suffice here simply to recapitulate the main points briefly. When the discharge is found, upon examination with the microscope, to contain tubercle bacilli, no further doubt can be entertained with regard to the nature of the disease. We are also warranted in feeling tolerably sure of our diagnosis when we find evidences, in other parts of the body, of the presence of tuberculous disease. The existence of multiple perforations in the membrana tympani, even when the presence of tubercle bacilli cannot be demonstrated, affords strong presumptive evidence of the tuberculous nature of the disease. The sluggish, asthenic type of the inflammation, the apparent ease with which bone caries develops, and the slight tendency of the tissues, or even the total absence of any tendency on their part, toward re-formation of the parts destroyed, furnish additional and strong evidence of the tuberculous nature of the disease.

A word more with regard to the search for tubercle bacilli. If we were to follow up all our cases of middle-ear discharge by carefully staining for the micro-organisms which are involved, I doubt not we should discover the tubercle bacillus where we never suspected it.

TREATMENT.—Under this latter head much or little might be said according to the view which is taken of the matter. It would seem perhaps better to consider first if there is anything specific for the tuberculosis which can be given as specific treatment *per se.* For example, lactic acid has been lauded in the treatment of tuberculous laryngitis, and has been thought by some to be almost specific in its working. Numerous experiments have been made in regard to tuberculosis of the ear, but, so far as I am able to judge, we have nothing for tuberculous disease in the ear which approaches being as nearly specific as lactic acid is for tuberculosis of the larynx. I have used this remedy by rubbing solutions of gradually increasing strength over the granulating surfaces in the middle ear, but have failed to get any better results than from other forms of careful treatment.

Iodoform has been recommended on account of the fact that it seems to act favorably upon tuberculous joints and bone tuberculosis in general. Perhaps it has some special usefulness in these cases, but I have not succeeded in obtaining specially favorable results. In view of the personal discomfort to the individual and to his environment which the use of iodoform always entails, and of the unfavorable results thus far obtained, I think it should never be employed.

Orthoform has been used in the advanced tuberculous cases in which the ulcerative process involved nerve trunks of sufficient sensitiveness to give more or less constant pain, and I have found that it acted, as it frequently does in the larynx, both to the comfort of the patient and to the cleaning up of the ulcerated surfaces.

The treatment then may be summed up under two heads: what the patient should do, and what measures the medical attendant should adopt. In mild cases in which the discharge is copious and the granulation tissue abundant, but without any involvement of the bone or any retention of large cholesteatomatous masses, the patient's portion of the treatment may be limited to the simple maintenance of cleanliness. A weak solution of carbolic or boric acid is to be syringed into the ear two, three, or four times a day, according to the amount of the discharge present. I have always found that the ear had less odor and was as a rule less offensive if, following the cleansing of the canal with an effective syringe, drops were instilled—as, for example, a solution of equal parts of glycerin and water containing one per cent. of zinc sulphate and two per cent. of carbolic acid. This simple astringent and antiseptic solution should be instilled warm into the ear.

In cases in which the granulation tissue seems to be abundant, equal portions of absolute alcohol and glycerin will be found to make an effective remedial solution for purposes of instillation. Before using this the ear should be very carefully dried out, as of course the effectiveness of this solution depends upon the hydrophilic properties of the materials employed. These instillations, if used at all, had better always follow the cleansing of the ear.

Peroxide of hydrogen is a much-used and in many quarters a much-lauded preparation, but it is more efficient when used by the physician himself than when given into the hands of the patient for daily use.

The physician who undertakes the treatment of a case of middle-ear tuberculosis should see the patient often enough to keep the granulations down, and if he succeeds in holding the disease in check, he has a right to believe that he is doing as well as can reasonably be expected.

It is only when the locality in which both physician and patient live possesses specially favorable climatic conditions that the former may hope to accomplish better results by the adoption of a more vigorous plan of treatment. Under ordinary climatic conditions, however, he should rest satisfied with the thorough cleansing of the ear; by which is meant that he should not merely syringe out the ear, but should also—by means of the swab and the curette, and by the use of the peroxide of hydrogen—remove all accumulations, of whatsoever nature, from every accessible place (more particularly the attic) where it may become lodged. After this has been accomplished, he should apply mild caustics to the granulating surfaces. If the latter are proliferating to such a degree as to produce polypoid masses, these should be removed by means of the snare or the sharp-edged curette. For simple stimulating purposes nitrate of silver, in strengths varying from fifteen to twenty per cent., will be found to answer well in this class of cases. Some authorities urge the necessity of using the stronger caustic preparations (chromic acid, nitrate of silver in the form of a solid bead) with great caution in cases believed to be of a tuberculous nature.

If the malleus is found to be necrotic, or the seat of a limited caries, this ossicle, together with all that may remain of the upper portion of the drum membrane, should be removed, in order that the freest possible drainage may be provided for the region of the attic.

Inasmuch as we can scarcely hope to do more than palliate the disease by the various measures which have been described above, and since it is further evident that even the most radical operative interference is not likely to be rewarded by materially better results, it is plainly our duty not to recommend these to this class of patients.

As regards the cases in which the tuberculous disease has produced such gross lesions as are shown in Figs. 1804 and 1805, it is not an easy matter to determine how far it is wise to proceed with surgical measures of a more or less radical character. Much will depend upon the condition of the patient's strength,—whether he can bear the strain of the operation,—and also upon the fact whether the sequestrum is or is not loose. If the patient's general condition is fairly good; if there are no evidences of meningeal, cerebral, or sinus involvement; and if the sequestrum appears to be of not too large size and disconnected from the surrounding living bone, it is fair to expect that operative interference will place the patient in a more comfortable condition and will probably prolong his life. That it can accomplish anything toward curing the disease is not to be expected.

As is so often the case with the treatment of these and other cases of tuberculosis, we can best sum up the whole affair by saying that each case will have to be treated thoroughly and solely on its individual merits or *pro re nata*.

Henry L. Swain.

EAR: SURGICAL ANATOMY OF THE MASTOID.—

The mastoid portion of the temporal bone takes its name from the nipple-like process which develops upon its outer surface to form the major insertion of the sterno-cleido-mastoid muscle, but it comprises all the part posterior to this which articulates with the occipital bone and forms a considerable element of the skull base. Its demarcation from the petrous portion is indefinite and can be but arbitrarily stated by assigning to the latter all that encloses the labyrinth; but from the squamous portion it is easily separable at birth, and sometimes in later life, and its line of suture with the tympanic scroll is rarely effaced by growth. Its outer anterior part is largely ensheathed by these portions, and, paradoxical as it may sound, much of our "mastoid operation" is done upon this extension of the squama (*vide* Fig. 1707, p. 622). Its surgical importance depends upon the liability of the tympanic structures within to incur septic infection, which is easily transmitted to it and to the more important adjacent structures, thus giving rise to a demand for intervention to eliminate such dangerous foci. Through the soft tissues, in life, little can be felt of the mastoid process except the convexity of the bony prominence, where the hairless skin and the periosteum form a thin covering, with only enough loose subcutaneous tissue to give free mobility to the skin (Fig. 1813). Inflammatory induration and œdema may distend this layer, however, to an inch or more in thickness, and so may render accurate palpation of the part impossible; but, so far as this difficulty is concerned, it is well to remember that, much as the two sides may differ in other respects, there is apt to be enough symmetry to make the other mastoid a fair criterion for the size and form of its fellow.

The mastoid process is a conoidal protuberance of the lower posterior portion of the temporal bone, and since it is in large part a response to the needs of the muscle inserted upon it, it shows an external form usually corresponding to the general osseous and muscular development of the individual; being large, rough, and massive in most strongly built males, and smaller, smoother, and thinner-walled in females and in males of slight physique. Its posterior boundary is partly marked by the deep groove of the digastric fossa, which intervenes between its apex and the skull base; anteriorly, its convex external surface slopes inward to become the back wall of the meatus. Above, it may be said to extend to the curving and often ill-defined temporal ridge which extends back from the root of the zygoma; but it is better to consider it as ending at the imaginary horizontal line on the level of the upper edge of the zygoma and the upper margin of the meatus. Almost exactly at the junction of these anterior and superior limits there may almost always be found a depressed groove or pit below which a spine or ridge projects toward the canal. This "suprameatal spine" (Fig. 1808), to which Henle and Bezold directed attention, is recognizable in the great majority of cases and forms a fixed and definite guiding-point not only for the mastoid but also for the whole skull. Kiesselbach found it in eighty-two per cent. of juvenile and eighty-seven per cent. of adult bones, and I have rarely missed it among my specimens or in four hundred mastoids operated upon.

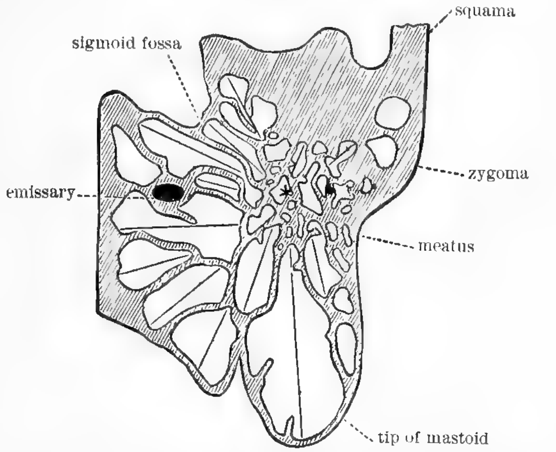

FIG. 1807.—Vertical Section of Mastoid Process at Right Angles to the Axis of the Auditory Canal, showing highly developed pneumatic cells and their radiating relation to the antrum ★. (After Eyssell.)

The mastoid process consists, externally, of a cortical lamina of compact bone, while in its interior it is more or less hollowed out by cavities, diploic or medullary in early life, but generally largely displaced, at a later period, by pneumatic extensions of the tympanum. As diverticula of the tympanic cavity these have a rather radiate arrangement in relation to it (Fig. 1807), and may extend not only throughout the mastoid but into all other portions of the temporal bone, and even inward, or backward into the occipital. They may be said to be always most marked in the large mastoids, fewer and more imperfectly developed in the less prominent ones. Zuckerkandl's finding that among 250 bones 36.8 per cent. were wholly pneumatic, and 20.4 per cent. wholly diploic, while in 42.8 per cent. various combinations of pneumatic spaces and diploë existed, has not been borne out by the writer's study of 500 temporals, which showed a surgically notable proportion of diploë in hardly 10 per cent. of adult bones. Whether the diploic or the pneumatic structure is the more prone to septic infection and transmission does not appear; and the spaces are devoid of known function except as aiding nature's economy of material in developing the process in response to the needs of the muscle inserted upon it. Their practical importance is that they in a sense hold away from the cortex the inner table and the deeper structures which are related to it.

These inner structures—which are the ones that concern us from a surgical standpoint—are the lateral sinus, the dura and brain of the middle cerebral and the cerebellar fossa, and the facial nerve; and while modern writings might seem to indicate that we now operate more often with the purpose of reaching than of avoiding them, it will yet always be a piece of bungling needlessly or unintentionally to expose, still more to injure, any of them.

The lateral sinus occupies the sigmoid sulcus which grooves more or less deeply the inner posterior surface of the mastoid. The vessel itself is of very varying size, partly because the current of the longitudinal sinuses is rarely equally divided at the torcular—the main flow being oftener to the right; and the impress which it makes upon the bone is still more variable. In general, the larger the sinus is the more deeply do its curves hollow out the sulcus, pressing closer to the external auditory canal, to the mastoid cortex, or to both. The usual thickness of bone externally covering it averages 7 mm. (0 to 20), and this thinnest place is at a point averaging 17 mm. (0.5 to

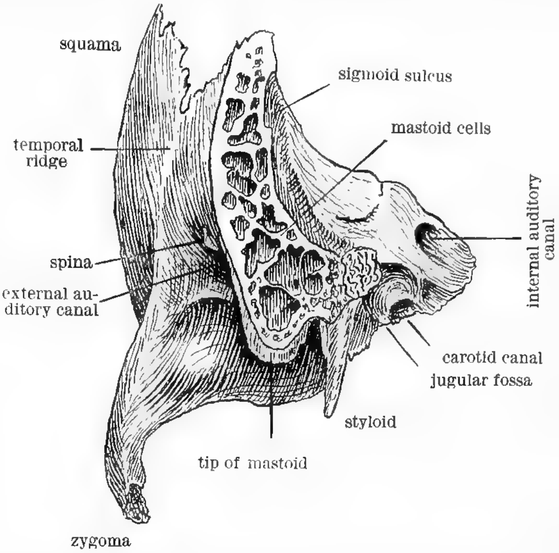

FIG. 1808.—Posterior Inferior Aspect of Temporal, sectioned nearly frontally to show the mastoid cells between the lateral sinus and the exterior, generally thin-walled toward the sigmoid sulcus and the digastric fossa within the mastoid tip.

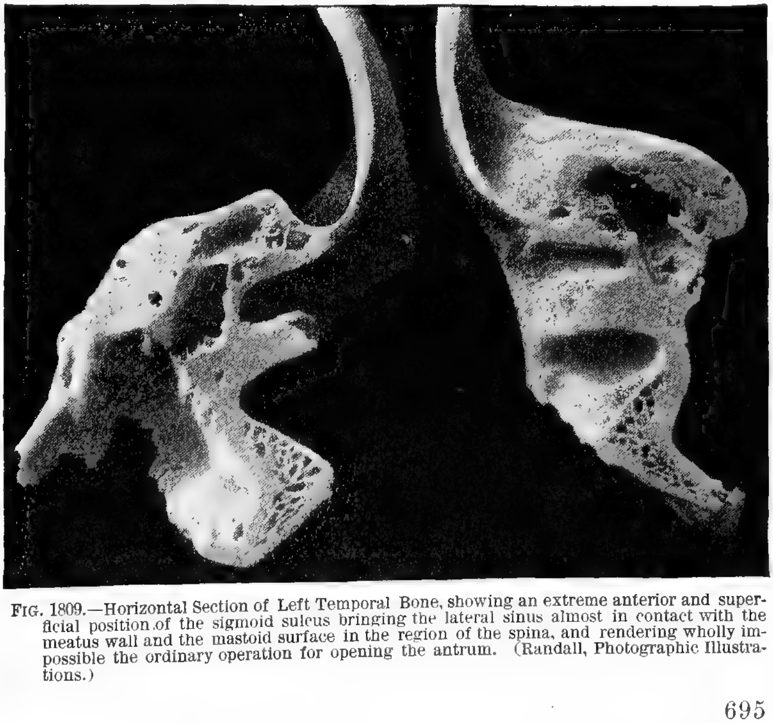

FIG. 1809.—Horizontal Section of Left Temporal Bone, showing an extreme anterior and superficial position of the sigmoid sulcus bringing the lateral sinus almost in contact with the meatus wall and the mastoid surface in the region of the spina, and rendering wholly impossible the ordinary operation for opening the antrum. (Randall, Photographic Illustrations.)

40) back of the suprameatal spine. It approaches within 12 mm., on an average (0 to 25), of the external meatus,

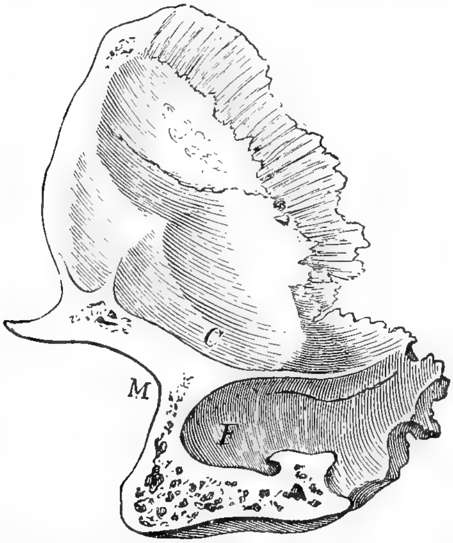

FIG. 1810.—Vertical Section at Right Angles to the Canal *M*, of a Diploic Right Temporal Bone, showing a forward and superficial position of the sigmoid fossa, *F*, and a middle cerebral fossa, *C*, lower than the temporal ridge. (After Hartmann.)

leaving a very moderate "operation space" through which the surgeon can penetrate to the antrum; but the minima stated (Fig. 1809) show that there can be no *assurance* of safe penetration in this direction, since no rule can be laid down by which the less favorable relation can be foretold. In spite of some assertions to the contrary it has been proved that the dangerous relations may be met in any type of skull and on either side. The only safe rule, therefore, is that of Hartmann, viz., to operate always as though the most dangerous relation were present until the contrary has been proved to be the fact. As regards its relations to the antrum, the sinus usually approaches it more nearly than it does either the

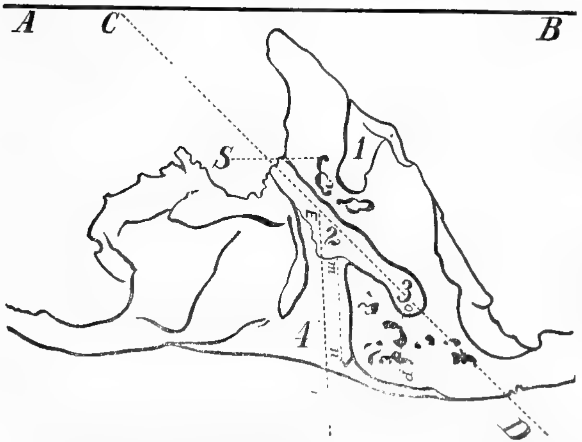

FIG. 1811.—Diagram of Right Temporal Bone Sectioned Horizontally and showing the Inclination of the Tubo-tympanic Axis, *C*, *D*, to the sagittal plane *A*, *B*; the length *m*, *n*, of the upper back wall of the meatus, and the depth, *o*, *p*, of the antrum from the operation point. 1, Meatus auditorius internus; 2, tympanic cavity; 3, mastoid antrum; 4, meatus auditorius externus. (After Allen.)

outer surface of the mastoid or the external auditory canal, and the intervening bone is commonly occupied by cells. As a rule, therefore, the operator, in his work upon the mastoid, is brought into immediate touch with the thin wall of the sulcus—a structure brittle and easily penetrated even when healthy. A large emissary vein passes back from the lower curve of the sigmoid, channelling the bone to emerge at the back of the digastric fossa near the occipito-temporal suture. In rare cases, as in the fellow of the mastoid represented in Fig. 1809, the entire sigmoid sinus emerges here; and again in other cases this emissary may be as large as a lead-pencil.

The floor of the middle cerebral fossa has been said to correspond fairly with the ridge extending back from the zygoma above the meatus; but this suprameatal ridge is no safe guide, since the fossa not infrequently extends below it (Fig. 1810). The average height is 6 mm. (0 to 18) above the *spina supra meatum* and the upper wall of the meatus, and this should form our landmark in entering the bone, as the fossa can never be below the meatus and is usually higher and back of it. An embryonic sinus not infrequently persists along the petro-squamous suture near the lowest part of the fossa. If the surface of the bone has been well bared, the surgeon will be able to distinguish the bluish tinge which is generally present when the sinus approaches very near to the external surface. The outer wall of the antrum is rarely less than 15 mm. from the surface. (Fig. 1811.) Hence, in the adult, a penetration to a depth less than this will generally fail to enter the antrum. In the infant, however, the latter cavity is situated much nearer the surface. Nevertheless, one who has merely noted that it is just below the surface in the new-born will be surprised at the thickness of the bone which has to be traversed even in very young children before the antrum is opened. With them, fortunately, the separation of the sigmoid sulcus from the meatus is often actually, as well as relatively, greater than in adults, and, besides, this relationship is more constant. Mastoid operations should therefore be safer and easier in children.

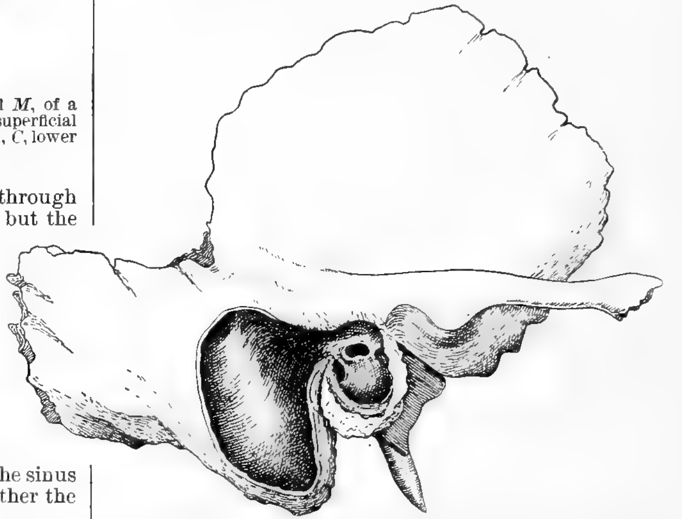

FIG. 1812.—Exenteration of Mastoid and Tympanic Cavities, showing prominence of facial canal above oval window, the sinus wall posteriorly, and the ridge covering the facial between.

The inner wall of the antrum is formed by the facial and semicircular canals (Fig. 1809); a fact which renders it dangerous, as regards the integrity of these important structures, unguardedly to enter this cavity, to curette its walls, or even in some cases to pack the cavity. Measurements indicate that the facial canal is probably never less than 12 mm. from the *spina*, although rarely more than 25 mm.; and the latter distance should in doubtful cases be the limit of our penetration even in a large mastoid.

The problem of avoiding injury to the facial nerve grows more difficult in exenteration of the tympanic cavity, in Stacke's operation, or in the more radical tympano-mastoid exenteration. In either case it must be remembered that the canal of the facial forms the upper lip of the fossa of the oval window, and curves thence backward and downward to a point situated from 3 to 4 mm. back of the middle of the posterior margin of the tympanic ring. While the descending part of the canal is usually exactly vertical, it seems clinically to pass somewhat outward, because we refer its course to the annulus and forget how very oblique the position of this really is. If we remove the tympanic margin above, without striking across to the inner side of the drum cavity (Fig. 1811), and in removing the posterior margin keep above its middle, the facial and its canal ought to remain untouched. A spur of bone at the back wall of the canal—largely the back portion of the tympanic scroll—will thus be preserved, and beneath this spur will be the facial canal (Fig. 1812).

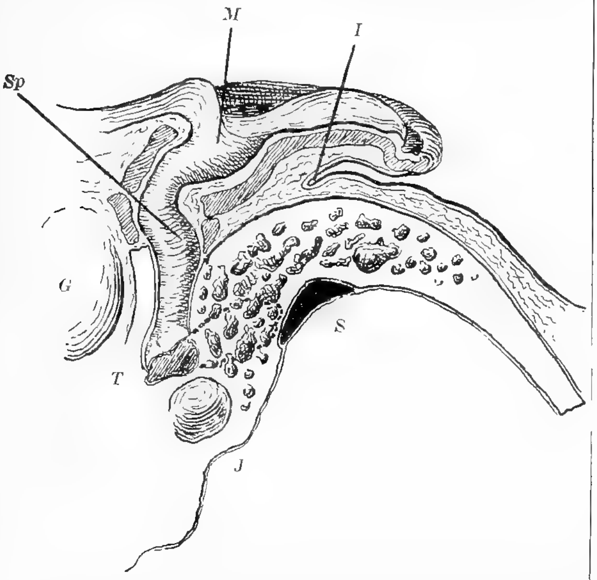

FIG. 1813.—Horizontal Section (upper half) of the Left Ear, with the Soft Parts in Place, showing the location back of the meatus, *M*, and the spina, *Sp*, of the posterior insertion of the auricle, *I*. The glenoid cavity, *G*, the tympanum, *T*, and the jugular, *J*, are also shown; and the sigmoid sinus, *S*, which in this case is safely distant from the field of operation, is seen to be most superficial opposite the insertion of the auricle. A dotted line indicates the antrum.

It is well to note the relation of the soft parts to the underlying bony structures, as some errors in regard to this are prevalent. The incision preliminary to opening the mastoid has generally been made 5 or 10 mm. back of the apparent insertion of the auricle and parallel to its curve, and some of the older surgeons considered the boss of the mastoid, at or behind this insertion, as the proper point for entering the bone. At the present time the chosen point of entrance is well in advance of this, in the region covered by the concha (Fig. 1813). The finger thrust into the meatus and pressed upward and backward can generally feel the spina, and it is at a point close behind this that the chiselling usually begins. The insertion line of the auricle, back of the meatus, corresponds to the average position of the sigmoid sulcus at its most superficial and anterior position, *i.e.*, about 15 mm. back of the spina. *B. Alexander Randall.*

EASTMAN SPRINGS.—Berrien County, Michigan.

POST OFFICE.—Benton Harbor. Hotel.

Benton Harbor is in the midst of the fruit belt of Michigan, 60 miles from Chicago and 90 miles from Milwaukee. The springs are nineteen in number. Following are analyses of some of the representative springs:

KING DAVID SPRING.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	0.11
Sodium bicarbonate	.67
Potassium sulphate	.14
Calcium bicarbonate	8.12
Magnesium bicarbonate	3.53
Iron bicarbonate	1.29
Manganese phosphate	Well-marked traces.
Alumina	
Silica	.11
	.58
Total	14.55

Carbonic acid gas, 38.96 cubic inches.

SILVER QUEEN.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains
Sodium chloride	0.09
Sodium bicarbonate	1.36
Potassium bicarbonate	1.07
Potassium sulphate	Traces.
Calcium bicarbonate	6.80
Magnesium bicarbonate	3.22
Silica	.11
Total	12.65

Carbonic acid gas, 35.46 cubic inches.

SILVER KING.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	0.10
Sodium bicarbonate	1.13
Potassium bicarbonate	1.05
Potassium sulphate	Traces.
Calcium bicarbonate	5.02
Magnesium bicarbonate	3.12
Lithium bicarbonate	3.03
Manganese phosphate	.01
Silica	.11
Total	13.57

Free of organic matter. Carbonic acid gas, 49 cubic inches.

BIMINI SPRING.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Potassium sulphate	.05
Sodium sulphate	.52
Sodium chloride	.10
Sodium phosphate	.01
Sodium borate	Traces.
Sodium bicarbonate	.26
Magnesium bicarbonate	3.55
Calcium bicarbonate	7.48
Iron bicarbonate	.07
Alumina	.03
Silica	.54
Total	12.61

Gas not estimated.

GOLDEN FOUNTAIN.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Potassium sulphate	0.11
Sodium sulphate	.26
Sodium phosphate	.04
Sodium chloride	.09
Magnesium sulphate	.18
Magnesium bicarbonate	3.21
Calcium bicarbonate	8.20
Iron bicarbonate	.38
Manganese bicarbonate	Traces.
Alumina	.01
Silica	.40
Total	12.88

Gas not estimated.

Other well-known springs are the "Colonel's Own," the "Saul," the "Psyche," and the "Winans."

This is quite a remarkable group of springs. They all appear to be more or less carbonated, some of them quite heavily so. They differ from most of the springs of Michigan in containing a much smaller proportion of chloride of sodium. The waters undoubtedly possess considerable medicinal value. Facilities for mineral and mud baths will be found at the springs; the waters are also used commercially. *James K. Crook.*

EASTPORT, MAINE.—Situated on the coast of Maine near the Canadian border, is a town of about four thousand inhabitants. It is an attractive place, located upon a small island on the western shore of Passamaquoddy Bay. It is not known as a seaside resort, although it affords a cool summer temperature and facilities for fishing and boating. Its climate is representative of that of the northern New England coast, a cool summer marine climate—as indicated by the following table. Fogs are frequent as at most other resorts upon this northern coast.

CLIMATE OF EASTPORT, ME. LATITUDE, 44°, 54′; LONGITUDE, 66°, 59′.
PERIOD OF OBSERVATION, APRIL 1ST, 1873, TO DECEMBER 31ST, 1883.

Data.	January.	July.	August.	Year.
Temperature (Fahrenheit scale.)				
Average or normal	19.7°	60.5°	60.8°	41.2°
Average daily range	15.9	17.2	15.6	
Mean of warmest	27.6	69.6	68.9	
Mean of coldest	11.7	52.4	53.3	
Highest or maximum	51.0	86.0	88.0	
Lowest or minimum	– 20.0	45.0	45.0	
Humidity—				
Average relative	77%	78.7%	78.9%	76.3%
Precipitation—				
Average rainfall in inches	3.15	4.82	3.16	48.91
Wind—				
Prevailing direction	N. W.	S.	S.	S.
Average hourly velocity in miles	12.4	6.3	5.9	9.7
Weather—				
Average number clear days	7.1	5.2	8.0	78.7
Average number fair days	12.3	14.0	11.5	134.3
Average number fair and clear days	19.4	19.2	19.5	213.0

Edward O. Otis.

EATON RAPIDS WELLS.—Eaton County, Michigan.
POST-OFFICE.—Eaton Rapids. Numerous hotels.
ACCESS.—From Jackson, Mich., viâ Grand River Valley Railroad to Eaton Rapids.

The town of Eaton Rapids is pleasantly situated on the Grand River. The wells were discovered in 1869 and 1870, and have drawn considerable attention to the place. Several of the wells are connected with the hotels, and all facilities for bathing are offered. The following analyses were made before the insertion of the first tubing, and it is probable that a considerable proportion of surface water was contained in that submitted for examination. The first three springs were analyzed by R. C. Kedzie and the fourth by C. T. Jackson:

One United States gallon contains.	Bodine Springs. Grains.	Mosher Springs. Grains.	Shaw Springs. Grains.	Sterling Springs. Grains.
Sodium carbonate	....	5.38	11.57	
Sodium bicarbonate	5.05			
Potassium carbonate	....	1.15	1.27	
Potassium bicarbonate	3.00		....	
Calcium carbonate	....	19.43	20.74	
Calcium bicarbonate	40.47			
Magnesium carbonate	....	4.52	3.84	
Magnesium bicarbonate	8.40			
Iron carbonate	....	....	....	2.80
Iron bicarbonate	2.25	1.00	2.23	
Sodium sulphate	....	....	....	12.59
Calcium sulphate	57.50	45.16	48.13	55.20
Magnesium sulphate	....	....	....	9.40
Sodium chloride	1.50	.90	.90	5.21
Silica	2.00	2.54	1.40	
Organic matter Loss	....	.85	.90	
Total	120.17	80.93	90.98	85.20
Carbonic acid gas	Cu. in. 17.35	Cu. in. 15.38	Cu. in. 15.97	Cu. in.

James K. Crook.

ECBOLICS AND EMMENAGOGUES.—Emmenagogues are remedial agents which stimulate or restore the menstrual function of the uterus when it is irregular or absent.

Ecbolics are agents which, by exciting uterine contractions, cause the contents of that organ to be expelled. Strictly speaking, this applies to foreign bodies and new growths like polypi and fibromata as well as to the products of conception, though the last is the usual interpretation. From the wide prevalence of the practice of criminal abortion ecbolics are the most abused class of remedies in the range of therapeutics. It is necessary to consider these subjects in conjunction with the pathological conditions for which they are employed. Were the uterus absent, amenorrhœa would continue in spite of all drugs. It is unnecessary to mention other pathological conditions that have a similar effect. Aside from such considerations, however, no doubt many different remedies act, with or without assistance, to increase the amount of menstrual discharge or to restore it, after long periods of amenorrhœa or at times when it would not appear at the expected time.

C. Martin, who carefully studied the subject of menstruation (*Brit. Gyn. Jour.*, November, 1893), reached the following important conclusions:

(1) Menstruation is a process directly controlled by a special nerve centre. (2) This centre is situated in the lumbar portion of the spinal cord. (3) The changes in the uterine mucosa during a period are brought about by catabolic nerves and during the interval by anabolic ones. (4) Menstrual impulses reach the uterus either through the pelvic splanchnics or through the ovarian plexus—possibly both. (5) Removal of the uterine appendages arrests menstruation by severing the menstrual nerves.

These deductions are in the main correct. However, abolishment of menstruation by removal of the uterine appendages is by no means constant. Clinical experience demonstrates the incorrectness of this statement. Excessive exercise or sexual indulgence or even desire, and strong emotions, will continue menstruation. Whether a diseased endometrium or uterine muscle is the direct cause cannot now be stated, though such occasional influence is not to be doubted.

Indications for the Use of Emmenagogues.—Two distinct varieties of amenorrhœa are met with. One of them, in which the appearance of menstruation is delayed considerably beyond the usual age of puberty, is known as *emansio mensium.* The other is called *suppressio mensium.* In the former we have first to consider the age and general condition of the individual. It is only in those cases in which the patient has reached the age of at least eighteen years that treatment should be attempted, unless the general condition or the environments of the patient be bad. When such conditions exist they should be righted, and if molimina be present some of the direct emmenagogues may be employed preceding or during the existence of the molimina, usually with happy results. Physical obstructions to the menstrual flow may exist and may later require investigation. Very rarely indeed are direct emmenagogues indicated in the treatment of delayed, scanty, or absent menstruation. Usually some faulty general condition of the patient exists, the menstrual disorder being merely one of the many symptoms present. It is one, however, to which much importance is attached by the mind untrained to such matters, and consequently it assumes the place of first importance and may indeed be the only complaint made by the debilitated or neurotic girl, or by one who is the unfortunate victim of tuberculosis. This matter is to some people of such seeming importance that a regular, scant flow of three days or a good amount of flow recurring regularly at slightly greater intervals than four weeks, causes them to seek the advice of the physician in attempting to increase the amount in the one case or the frequency in the other. The usual training received by girls during the first five years of menstrual life is unfavorable to the proper development of their genitalia. It likewise debilitates or prevents their general physical development. The nervous system is usually overtrained and as a result the proportion of neurotics large. A markedly intimate relation exists between the nervous and reproductive systems; the neurotic origin of menstrual abnormalities is clear.

The Therapeutic Use of Emmenagogues.—The remedies which act directly on the uterus to increase the amount of menstrual flow are called *direct* emmenagogues, and those which act by changing the general condition of the patient and thereby increasing or producing the menstrual flow are named *indirect* emmenagogues. The latter class is important and comprises not only the tonics, as iron, arsenic, copper, manganese, gold, digitalis, barium chloride, strychnine and quinine, but also salicylic acid and its salts, Cocculus indicus, Lappa officinalis, and such external applications as the spinal ice-bag and baths.

The principal direct emmenagogues are ergot, oxalic acid, apiol, binoxide of manganese, santonin, eumenol, indigo, aloes, Menyanthes trifoliata, permanganate of potassium, turpentine, cantharides, myrrh, rue, savin, tansy, pennyroyal, guaiac, American mistletoe, senecio Jacobœa, cimicifuga, saffron, cotton root, quinine, pulsatilla, water pepper, serpentaria, aconite, sage, chamomile, blue cohosh, leeches to the cervix, warm vaginal douches, sitz baths, and local applications of electricity.

It is evident from the long list of direct emmenagogues that a short route to success in the treatment of menstrual disorders is frequently attempted, in spite of the well-known fact that they are usually due to some general vicious condition. By such treatment it may be possible to produce the menstrual flow once or twice in most cases, but the previous condition recurs. It is only by treating the underlying general condition that success is to be expected.

In such general conditions as tuberculosis, carcinoma, and syphilis amenorrhœa is probably a conservative feature and should receive no treatment. Anæmia is the principal cause of lessened menstrual discharge and calls for the tonics mentioned. An elixir of the seeds of the common burdock (Lappa officinalis), in the dose of a teaspoonful after each meal for a period of a month, has been highly recommended for suppressed menstruation in young girls. Digitalis, by increasing the arterial tension, acts well in many cases. Salicylic acid and the salicylates are the most efficient remedies when a uric-acid diathesis underlies the suppression. Guaiac, though generally considered a direct emmenagogue, certainly acts well in this condition. Phillips strongly recommends picrotoxin, the active principle of Cocculus indicus, in doses of gr. $\frac{1}{60}$ to $\frac{1}{12}$, in anæmia with amenorrhœa. The preparations of iron, especially when combined with manganese, are favorite remedies for such conditions. General galvanization and faradization are useful as general tonics. The ice-bag applied to the lumbar spine has a stimulating and tonic action on the nervous system, especially the vaso-motor portion. It increases the amount of menstrual flow by engorging the pelvic blood-vessels and stimulating the centre of menstruation. General bathing in cold water, sea-bathing, brisk rubbing, and the cold plunge often prove to be efficient indirect emmenagogues.

The usual accompanying constipation is best treated by aloes and myrrh or by carbonate of magnesia. Aloes and myrrh act by engorging the pelvic viscera. The magnesia salt is given in delayed menstruation in doses of gr. xxx.–xc. The smaller dose may be given nightly for a fortnight, but afterward the larger dose should be prescribed until the flow appears. After the continued use of general tonics direct emmenagogues are often indicated. The simplest consist of the sitz bath, pediluvia and external friction, to which may be added hot drinks (infusions) of cinnamon, chamomile, ginger, tansy, pennyroyal, water pepper, sage or serpentaria, all of which act as relaxants or diaphoretics. Some, however, act as stimulants to the pelvic circulation. White (*Lancet*, London, 1895) praises wineglassful doses of Menyanthes trifoliata. Ergot, though a pronounced direct emmenagogue, acts best in small doses with iron. Guaiac is valuable in anæmic amenorrhœa, but it should not be administered except in combination with other agents. It may be given for weeks without danger. When heavy nerve strain has produced irregular or delayed menstruation, a combination of strychnine, aloin, and atropine is of signal benefit. The bromides are also often useful in this class of cases. The compound sumbul pill (Goodell's formula), consisting of iron, sumbul, asafœtida, and arsenious acid, is valuable when nervous manifestations accompany anæmia. Physical shock has been known to restore the menses when other remedies had failed. Aloes acts well in obesity by depleting the system and engorging the pelvic circulation. The spinal ice-bag is here useful. When the flow is absent as a result of "taking cold," general treatment in the way of hot baths and cathartics to the extent of restoring the circulatory equilibrium, is required. Aconite acts well in such cases, especially when given in hot water. A few days before the expected flow the employment of nearly any of the direct emmenagogues has a marked tendency to restore the menstrual function. Most of the direct emmenagogues act by stimulating the centre of menstruation in the spinal cord. Ergot acts as a strong stimulant upon all unstriped muscular fibres, in doses of gtt. x. to xxx. daily; combined with iron it is a splendid though treacherous emmenagogue. V. Poulet (*Arch. de Toxicol.*, Paris, 1886, xiii., 539) first called attention to the emmenagogue action of oxalic acid. Since then it has been largely employed with gratifying results. It is not without danger, as pointed out by Talley, who noted marked prostration and partial collapse following a small dose of the drug. One-quarter grain every four hours in syrup of orange or lemon may be given for a few days preceding the expected flow. Apiol, used just preceding and during the period, is best given in pill form, in doses of gr. i. or gr. ij. after meals, for a period of from one day to several weeks. Ringer says it will restore the flow in young girls after a lapse of two years. It is useful in amenorrhœa from seasickness and in women between the ages of thirty and forty who are rapidly increasing in weight and in whom the flow is decreasing. Manganese binoxide may be employed advantageously under similar circumstances. Santonin is principally employed when anæmia complicates the absent flow. Its beneficial action appears to depend upon its power to cause contraction of the engorged uterus. It is given in ten-grain doses at night for two nights preceding the time when the flow is expected. The dose is large and the drug treacherous. Its use will never be popular on this account. Local faradization and the application of the negative galvanic pole against the cervix or in the cavity of the uterus have been resorted to with moderate success. The results of the use of indigo have not been such as to give it a prominent place in this list. Eumenol, Merck's preparation of the Tang kui root, is strongly indorsed by Mueller and Hirth. It has been employed for centuries in China as an emmenagogue. Turpentine and cantharides are dangerous emmenagogues because of their tendency to irritate the urinary organs. Pennyroyal, rue, savin and tansy are unreliable and dangerous by reason of their liability to produce gastro-intestinal irritation and because they exert an ecbolic action. The American mistletoe and cotton seed are largely employed, in the form of infusion, in the West and Southwest for menstrual suppression due to cold, and undoubtedly they have merit. Leeches to the cervix are troublesome and of little value. The bleeding following their removal is often severe.

Ecbolics.—Nearly all the direct emmenagogues given in the usual doses are ecbolics, and in still larger doses they check the flow. Direct emmenagogues should never be employed when the existence of pregnancy is probable. The principal ecbolics are ergot, apiol, quinine, rue, savin, tansy, pennyroyal, cotton root, oxalic acid and turpentine. Ergot is the strongest in its action, but many others like cotton root, pennyroyal, and cantharides, are employed by ignorant people as ecbolics. Oxalic acid is unquestionably an ecbolic. Carter says that the American mistletoe produces more prompt and sure uterine contractions than ergot. Manganese dioxide has a similar action, cases of abortion from its use being recorded. The ecbolic action of quinine is probably less than is believed. That it has the power to strengthen uterine contractions cannot be doubted. All these drugs are dangerous in their action and should not be employed without a thorough familiarity with their actions and dangers.

J. Wesley Bovée.

ECLAMPSIA INFANTUM.—(Synonyms: Convulsions in children; acute infantile epilepsy; spasms.) By eclampsia in children is meant a variety of convulsions, more or less general, occurring with or without prodromal manifestations, and not dependent upon any material organic lesion of the nervous centres. Most authorities regard absolute abolition of consciousness as an essential element of eclamptic as well as of epileptic attacks. This loss of consciousness need not persist during the whole attack, but must have occurred at some part of it. It is true that there are attacks of very slight spasms in children in which it is difficult to be positive that consciousness has been lost, by the application of such imperfect tests (irritation of the conjunctivæ, etc.) as these little subjects will admit; but analogous attacks in adults prove that loss of consciousness, however brief, is an essential element of an eclamptic convulsion. An important point in the differential diagnosis between an attack of eclampsia and one of epilepsy is, that in the former the convulsions are not repeated in a series. It is true, attacks of eclampsia may be repeated, but unless the repeated attacks can be shown to have depended upon one or other of the conditions which ordinarily give rise to eclampsia, every repetition of the convulsion renders our suspicion as to its epileptic character stronger.

In describing an eclamptic seizure, it is important to remember that the convulsion differs in no way from an attack of epilepsy. Hence a general clinical picture of the disease will be that of an ordinary epileptic spasm. There may be an aura, a cry, then convulsive movements in some of the voluntary muscles, proceeding rapidly to more or less general convulsions, at first tonic, then clonic in character. There is loss of consciousness, generally, before the tonic convulsions have set in, the little patient may froth at the mouth, the tongue may be bitten, the respiration is that characteristic of epileptic attacks; finally the spasm is often followed by sleep. It is evident, then, that we must not depend upon the character of the convulsion for a differentiation between epilepsy and eclampsia, although a careful study of the clinical history of the case will generally give us the data necessary to a correct diagnosis.

Clinical Occurrence.—Nothnagel[1] and Ozanam[2] discuss the possibility of the occurrence of eclampsia infantum as an idiopathic affection. The latter authority limits the term eclampsia to convulsions of non-epileptic origin, occurring independently of other diseases or pathological conditions. Nothnagel, however, includes under the term eclampsia convulsions which are the reflex expression of some peripheral irritation, such as dentition, etc. The convulsions occurring at the outset of acute infectious diseases and acute inflammations he terms simply epileptiform, a term that might be applied to all varieties of eclamptic attacks. Eclampsia infantum should be considered not so much a disease as a symptom of other diseases; in one case the convulsion may only precede or usher in a pneumonia, in another it may appear at the same time with a brilliant scarlatina; here dentition appears to have been the exciting cause, there the ingestion of indigestible food; in all of these conditions the attacks resemble each other, although in each case the clinical etiology is different. Looking, then, upon eclampsia from an etiological standpoint, it appears that all the possible conditions under which eclamptic attacks may occur in children will come under one of the following subdivisions:

1. Febrile or symptomatic eclampsia.
2. Reflex eclampsia.
3. Toxic eclampsia.
4. Eclampsia of rachitis.

Febrile or Symptomatic Eclampsia.—The most common form of eclampsia occcurring in young children is undoubtedly the first group, the febrile or symptomatic eclampsia. By this class is meant that form of eclampsia which occurs, as a rule, at the *outset* of febrile diseases; we say at the outset, to distinguish these initial convulsions from those occurring later on in the course of severe inflammatory conditions, and due not so much to the fever as to cerebral adynamia, or the aggregation of toxic elements in the blood as a result of the disease. So commonly does a convulsion mark the outset of inflammatory disease and acute infectious fevers of infancy, that it would almost appear that in these little patients the eclamptic seizure corresponds to the chill which ushers in similar diseases in adults and grown children. This substitution of a convulsion, an eminently nervous phenomenon, for a chill, corresponds to the exalted irritability of the nervous system characteristic of infants. This excess of irritability is especially marked in the medulla oblongata; and since the studies of most observers, among others Schroeder van der Kolk,[3] point to the medulla as the starting-point of the changes resulting in an epileptiform convulsion, the increased liability to convulsions at this early age is readily explicable. How shall we explain the occurrence of this febrile form of eclampsia? Is the convulsion due to the fever, or to some mysterious infection of the blood by the poison of the disease of which the fever is a symptom? Authorities differ as to this point, the tendency being to individualize and explain the occurrence of the eclampsia in distinct ways for different diseases. In the first place, in inflammations of the brain and meninges the convulsions are not eclamptic, being dependent upon a material lesion of the nervous centres. But the eclampsia introducing an attack of pneumonia, pleurisy, measles, or scarlet fever, how is this produced? Steiner[4] considers the convulsions which precede an attack of pneumonia as the reflex result of the irritation of the peripheral filaments of the pneumogastric distributed to the congested lung. The weakness of this explanation does not lie in the fact to which Soltmann[5] calls attention, that eclamptic convulsions do not occur in all cases of pneumonia in children, but rather in this, that the convulsions are not so frequently repeated as we should expect were this theory true, for the lung remains congested during many hours, while the convulsion lasts but a few minutes, and in many cases is not repeated. We do not think that any further explanation of the eclampsia of the early stage of pneumonia need be given than that it is due to the high temperature which ushers in the disease. The rapid and bounding pulse, characteristic of the febrile process, produces cerebral hyperæmia, the already over-excitable medulla is rendered more excitable, and a convulsive discharge of nerve force takes place; the cause here is evidently simply increased temperature, and its recognition serves as an important indication for treatment.

In the acute infectious diseases, one might readily be excused for supposing that the initial convulsion is most probably due to the altered condition of the blood. The bacteria of scarlet fever, as well as those of measles and diphtheria and other infectious diseases, may well have so changed the blood, even in the opening stages of the disease, as no longer to enable it properly to nourish the nerve centres; accordingly such writers as Soltmann[5] and Henoch[6] consider that the eclampsia, even in the onset of these diseases, is mainly due to the toxæmia; and yet these convulsions frequently do not occur in the most severe cases, and do occur in the mild ones. The toxæmia must be regarded as varying in direct proportion to the severity of the affection, and the same should be true of the convulsions to enable us to accept the view of Henoch. We do find, however, that in most of the cases in which convulsions have occurred, the temperature was very high, irrespective of the severity of the disease. I recall a case in my own experience, similar to one reported by Hunter,[7] in which, with the onset of a varicella, the temperature rose to 105° F., and the child had two eclamptic convulsions; on the succeeding day the temperature had fallen and the little patient was able to run about in the room. One can cause the cessation of repeated eclamptic attacks in a case of commencing infectious disease by the application of a cold bath. For these reasons it would appear that in these cases also the active cause of the convulsion is the increased heat of the body. It must be acknowledged, however, that there are cases in which the specific toxæmia of the disease is so great that the nervous centres are completely overwhelmed. In these cases the convulsions are really toxic in character, and are far more fatal than those depending upon the fever; here, too, we shall often find upon post-mortem examination inflammatory disturbances of the brain and spinal cord. In the vast majority of cases of eclampsia occurring early in the course of infectious diseases, reduction of temperature will result in cessation of the convulsions. The diseases in which this febrile form of eclampsia may occur include almost all of the febrile affections of childhood, that is, all of the acute infectious diseases, among which must not be forgotten erysipelas and typhoid fever; also all of the inflammatory affections of the respiratory organs, such as laryngitis, bronchitis, pleurisy, and pneumonia; and the acute catarrhal, croupous, and diphtheritic affections of the throat and pharynx. Febrile eclampsia, although more frequent at the outset of febrile diseases, may occur later on in the course of these diseases. As already stated, the eclampsia then occurring is, as a rule, dependent upon blood changes; but not necessarily, for although the nervous system of the child seems to become habituated to mere elevated temperature, yet a great and sudden rise of the fever at any stage of the disease may produce a convulsion. Thus, I have seen a convulsion occur in a child suffering from a pneumonia on the evening before the critical day, the convulsion being simultaneous with the highest rise of the temperature curve.

Malarial fever, according to many authorities, frequently has the chill which ushers in the paroxysm in adults, replaced, in children, by a convulsion.

Malarial eclampsia, so called, is most frequent in infants under three years of age suffering from intermittent fever. In older children the convulsion is absent while the chill is present When the convulsion takes the place of the chill it is said to be exceedingly severe and may last for hours; sometimes each recurrence of the malarial paroxysm is accompanied by a convulsion. Dubrisay[8] reports a case in which the convulsion recurred with eleven distinct malarial paroxysms. These convulsions are probably toxic in character.

Parotitis, when accompanied by high fever, may be an etiological factor in the production of an attack of eclampsia. Dysentery, gastritis, cholera infantum, all of these when accompanied by high fever may produce a convulsion. Here again, however, we must distinguish the febrile convulsions from those which occur in the later stages of these diseases and are dependent upon the cerebral vascular changes, of which the depressed fontanel is so characteristic a symptom. In conclusion, it may be said that any affection accompanied by high fever may result in an eclamptic attack in infants.

Reflex Eclampsia.—By the term reflex eclampsia, which is the second subdivision under which we shall discuss the subject, we mean that form of eclampsia which is the reflex motor expression of some peripheral irritation of sensitive nerves. Such motor manifestations as a reflex result of peripheral irritation are not unfamiliar, even in adult life; as an instance we have the hysterical, and even epileptic, manifestations in females as a result of uterine disease. In infants the inhibitory action of the brain over the spinal cord is still in abeyance, and reflex action is more uncontrolled; there is an exalted irritability of the spinal cord, and hence these little patients are excellent subjects for the full manifestation of the evil effects of a constant peripheral irritant. Among the most constant of these peripheral irritants during infant life is dentition, and this is accordingly the most frequent cause of reflex eclampsia. There are those who believe that dentition, being a physiological process, cannot be connected with the production of so serious a pathological condition as convulsions, but they are of right in the minority. When it shall have been proved that other physiological processes are never productive of serious morbid states, then we shall give some credence to such a view; for the present, it is emphatically the opinion of the vast majority of authorities that difficult dentition is frequently the only assignable cause for a series of eclamptic attacks. The convulsion is often followed in a short time by the appearance of one or two teeth; some children have a convulsion preceding the breaking through of almost every tooth. We deprecate the assigning of dentition as a cause for almost all the diseases to which infant life is liable; but, on the other hand, we place this physiological process as the chief among the peripheral excitants which sometimes result in reflex eclampsia in infants. To account for the occurrence of these convulsions during the period of first dentition, and their almost uniform absence during that of the second, it is only necessary to remember that the condition of exalted irritability of the nervous centres, which is present in infants, is not present in the older children; hence a similar, or even greater irritation will fail to produce a convulsion in the older child, which in the infant might have produced a serious eclampsia. The gastro-enteritis, which is one of the direct results and a concomitant condition of difficult dentition, may cause an attack of eclampsia in teething infants. In this case we would consider the eclamptic attack the result of the toxæmia caused by the auto-infection from the stomach and intestinal tract, and not due to an irritation of the peripheral nerves terminating in the gums. For an excellent discussion of the subject of dentition eclampsia I would refer the reader to Fleischmann[9] and Politzer.[10]

Helminthiasis is another condition which is supposed by many authorities to give rise in some cases to eclampsia infantum. Such convulsions occur more frequently with the larger worms (round worms, tænia). I recall a severe epileptiform attack in an adult, who had never suffered from epilepsy, which preceded the expulsion of a tapeworm. Other authorities give undoubted cases in which the convulsions were the precursors of the discharge of large quantities of worms. It must not be forgotten, however, that the convulsions may depend upon the intestinal catarrh which is the result of the helminthiasis. Here, again, the toxæmia resulting from the auto-infection from the bowels is the cause of the convulsions. The auto-infection may also be caused by the absorption of toxic products specific to the parasite or such as arise from undigested food due to the catarrhal enteritis produced by the presence of the parasite.

The irritation of indigestible food, or food in too large quantities, may be the cause of a convulsion. In these cases, again, the convulsions may be reflex in character as a result of the irritation of the indigestible matter in the stomach, or they may be produced by an acute rise of temperature; finally, the spasm may be the result of a toxæmic condition of the blood. If the attack be the result of the irritation of indigestible food, it generally occurs soon after the ingestion of the offending nutriment. Children vomit so readily that emesis will generally free the stomach from this irritant, and thus prevent a repetition of the attack. This cause of eclampsia has been acknowledged and well recognized as far back as the time of Hippocrates.

I am disposed to class under this head the occasional attacks of eclampsia resulting from præputial irritation and masturbation[11] in children. Where these attacks are frequently repeated, they would with more propriety be classed as epileptic. Other peripheral irritants have been observed, by good authorities, to produce convulsions in children. Soltmann mentions a case in which ascent of the testicles into the inguinal canal resulted in a convulsion. Foreign bodies in the ears have been repeatedly shown to be active in the production of a convulsion. Scalding of the surface of even a small portion of the body, or any other extremely painful, sudden injury, even if of short duration and of slight character, has been sufficient to produce an eclamptic attack.

Toxic Eclampsia.—The group of toxic eclampsia, although least understood, is by far the most interesting. In this class I include all eclamptic attacks which seem to depend upon some blood change which renders it unfit to nourish the nerve centres. We do not know enough of the changes produced by different diseases in the composition and constitution of the blood to enable us to state, with even an approach to positiveness, the exact alteration upon which this toxic action of the blood depends. In some cases it may be that there is a change in the quantity or quality of the constituents of normal blood; in others foreign substances (toxins) may have appeared in addition to the normal ingredients. We cannot here enter upon a discussion of the various kinds of toxæmia and bacteræmia which cause the septicæmia in the different diseases, but the fact is undisputed that the blood in such conditions acts as an irritant to the nerve centres, and this irritation manifests itself in eclamptic seizures. One fact seems to be characteristic of this form of éclampsia, and that is, that the attacks do not occur at the outset, but generally in the course of a disease. To this group belong the convulsions which occur in the course of a pneumonia as a result of the insufficient aëration of the blood [12]; and here also belong the convulsions (Stickungskrampf) accompanying the dyspnœa of severe croupous and diphtheritic laryngitis, and those accompanying the dyspnœa of prolonged attacks of laryngismus stridulus and whooping-cough. As will be seen later on, in every complete epileptiform attack the clonic convulsions are the result of the strangulation produced by the early tonic spasm of the respiratory muscles, and it is therefore not surprising that similar clonic convulsions occur in diseases whose chief clinical manifestation is spasm of the respiratory muscles.[13] An important class of cases belonging to this group is the eclampsia of scarlet fever, which is the result of a concomitant kidney affection with albuminuria. The retention of the urea in the blood is the cause of the convulsion. The occurrence of eclamptic attacks in primary or secondary parenchymatous nephritis is a frequent symptom in these conditions of the kidney. The convulsions occurring in the course of acute diseases which are non-febrile, but which seem to be dependent upon the action of the poison of the disease process, are well recognized, although we cannot define the nature of the toxæmia in each individual case. We must not forget to mention, under this head, convulsions occurring as a result of permitting infants to nurse at the breast of a mother who has undergone some severe fright or mental shock. At the risk of being accused of belief in what is vague and unproven, I must express my conviction that nervous shock certainly does impair and alter the character of the milk secreted by the mother. The experience of ages teaches that a frightened mother should not nurse her child.

Eclampsia of Rachitis.—The eclamptic attacks which occur in rachitic children we place in a separate group, partly because eclamptic attacks are very frequent in rachitic children, owing probably to the especially exalted irritability of the nervous system, which is characteristic of rachitic children; but chiefly because one variety of eclampsia occurs in rachitic children exclusively: this is the condition known as laryngismus stridulus or laryngeal eclampsia.

Although, theoretically, all cases of eclampsia ought to fall under one or more of the four groups into which I have divided the subject, yet clinically there may be cases which will not seem to depend upon any one of the assigned causes, and will have to be classified as a separate and distinct group, termed idiopathic eclampsia—in other words, cases that cannot be classified etiologically. This group will probably diminish with knowledge and improved methods of examination.

ETIOLOGY.—It has already been stated that infants have a marked predisposition to the occurrence of attacks of eclampsia. Why this should be so has occupied the attention of many excellent observers, among whom may be mentioned Nothnagel and Soltmann, the latter of whom has written a monograph on the peculiarities of function in the brain and spinal cord of infants. Clinically, we recognize that children under two years of age are more frequently seized with eclampsia than children beyond that age. So frequent is this disease in infancy that it may be counted as the most fatal pathological condition to which infancy is liable. By this is not meant that the prognosis of all attacks of eclampsia is necessarily bad. On the contrary, the prognosis is very good, but so frequent is the condition itself that notwithstanding its comparatively favorable prognosis it still causes the death of more infants than does any other affection. The fact that it occurs most frequently during the period of dentition led many of the older writers to ascribe eclampsia to the dentition process; but the exalted reflex irritability of the spinal cord in infants, as already set forth, is the only element necessary to account for the predisposition to convulsions shown at this time of life. Heredity is an additional factor which helps to augment this natural predisposition. Most physicians in active practice will recall families in which all of the children have "spasms," while in other households such a thing is entirely unknown. A careful examination will generally reveal the fact that in the former class of patients the parents are of a nervous temperament; there may be a history of insanity, paralysis, or convulsions in other members of the family; in other words, these patients give a neurotic family history. It does not appear that either sex shows any predisposition for the disease. Male and female children seem to be equally liable to convulsions; if individual experience is of any value in this connection, I think I have observed more children with convulsions among the male sex than among females. As to the exciting causes, they have been thoroughly discussed in a previous paragraph.

Rickets is a frequent cause of eclampsia, owing to a variety of pathological conditions which, while they are the direct result of the rachitic changes in the tissues and fluids of the body, affect the brain and spinal cord more especially. Such convulsions, when the result of a gross lesion of the brain and spinal cord, are not to be classed as true eclampsia for the purpose of this article. Frequently eclamptic attacks in rachitic children are the result of a febrile, reflex, or toxic condition, insufficient in degree to have produced convulsions in healthy children, yet sufficient to disturb the balance of the delicately poised nervous system of these rachitic patients; so that the presence of rachitis is a predisposing factor in the causation of convulsions.

In addition to this, as we shall see when discussing the pathology of eclampsia, laryngismus stridulus is a form of eclampsia affecting rachitic children exclusively. It is the result in most cases of an auto-infection caused by the absorption of toxic materials produced in the stomach and bowels of rachitic children. This toxæmia thus produced, acting upon the extremely irritable nervous centres of rachitic children, initiates a central irritation passing to the motor nerves of the larynx.

It would, however, appear that such a selective action of the toxic products of the blood upon the central origin of the laryngeal motor nerves must necessarily be initiated and aided by an irritation passing from the respiratory tract, of which the glottis is the entrance, to nerve centres. Such an irritation is found, first, in the catarrhal conditions affecting the respiratory tract of rachitic children; second, in the malformations of the thorax characteristic of rickets; third, in the inflamed, enlarged, and frequently suppurating bronchial glands, which by pressure upon the motor and sensory nerves of the larynx, initiate or aid an irritation which finds its peripheral expression in an attack of laryngo-spasm.

SYMPTOMATOLOGY.—A typical attack of eclampsia may be divided into two stages: First, the prodromal stage; second, the convulsive stage.

It is necessary to state that in many cases the first stage is entirely absent, and the second is so brief as to be scarcely noticeable. Many authorities have considered that the symptoms described under the head of premonitory symptoms are simply the marks of the general disturbance, of which the eclampsia is the result. Thus restlessness, a premonitory symptom to which all writers draw attention, may simply be a sign that there is something wrong with the little patient, without really foreshadowing a convulsion. There can be no doubt, however, that many children who are about to have a convulsion show this by a certain aggregation of phenomena which, to the anxious mother who has already experienced a convulsion in her infant, are the mutterings preceding the coming storm. In one variety of cases the child, which has been in good health, is observed to be feverish. There is a flush in the face, or the countenance may be exceedingly pale. The sleep is restless, the child starts, it grinds its teeth. As it lies dozing it may smile occasionally, or there may be a convulsive twitching of the lips and muscles of the face. The eyes are half closed, the nostrils move irregularly. It throws its arms and legs about, occasionally it sighs deeply, the breathing is irregular, although not stertorous; now and then the whole body starts violently, sometimes waking the patient and causing it to cry fretfully, to be followed again by drowsiness. These cases may be termed the somnolent cases. There are others in which the picture is an entirely different one. The little one is abnormally wakeful, it appears to be more than usually bright, the cheeks are flushed as though with hectic; the eyes sparkle, the pupils are enlarged; the muscles of different portions of the body twitch—now a finger, or arm, or leg, sometimes the eyelids, again the face—the child laughs more than usual, will not rest in the lap of its nurse, seems to prefer activity to rest, and asks to be taken from one attendant to another. The abnormal brightness and restlessness increase, until suddenly the little patient is thrown into violent convulsions. In these cases the parents will relate how bright the child had been before its spasm. There are other symptoms which may well be termed premonitory, although not so frequently observed as the two varieties just described. Thus I recall a little one who, in four out of six attacks of eclampsia (dentition), vomited a few minutes previous to its attack. There are other children who have many of the above-described symptoms without having an attack of eclampsia. In these cases the absence of the complete convulsion is due to a more than usually well-balanced nervous system, which, while yielding to the irritant to a certain extent, does not lose control of the "organ of mind" to a sufficient extent to place the body under the influence of the purely reflex nervous centres. Many cases have a convulsion without any of the above-described premonitory symptoms, or rather without any having been observed. There may not even be a cry, but suddenly the child falls into a more or less general and violent epileptiform spasm. The convulsive stage follows the prodromal symptoms after a shorter or longer period. But the prodromal stage, as has already been stated, may be entirely absent, or so little marked as to escape notice; then the convulsion proper sets in suddenly, often runs a rapid course, and the child recovers without sequelæ, so that before the physician has arrived the child appears bright, and as though nothing had happened. This convulsive stage of eclampsia exactly resembles the convulsive stage of epilepsy. Indeed, most writers have agreed that the attack as such is indistinguishable from an epileptic seizure (Reynolds, Hughlings Jackson, Niemeyer, Brown-Séquard). While this is true for a typical attack of eclampsia, as compared with a typical attack of epilepsy, we shall call attention to several points peculiar to some attacks of eclampsia when we come to consider the subject of differential diagnosis. The little patient, who may or may not have presented the premonitory symptoms above described, is suddenly heard to cry out; the cry is immediately followed by a tonic spasm of the voluntary muscles; the body is thrown into the position of opisthotonus, the head is drawn back, the veins of the neck stand out prominently; the arms are rigid, abducted, and partially pronated; the hands are tightly clinched; there is a gurgling sound heard from the throat, as though the patient were choking; the teeth are firmly closed, the face is at first pale, but gradually grows congested and dark; the pupils are dilated, the eyes being open. This tonic spasm affects muscles of respiration as well as the voluntary muscles, and it is owing to this fact (Schroeder van der Kolk) and the interference with the venous return from the brain that the other clonic stage of the convulsion is due—that is to say, the clonic spasm is the asphyxial convulsion.

Fortunately the severe tonic spasm is but a few seconds or a minute in duration; were this not so, death from asphyxia during the tonic spasm would be more frequent. Even as it is, death sometimes occurs at this stage of the spasm. In the largest number of cases the brief tonic spasm is followed by clonic general convulsions. The extremities are alternately flexed and extended, the arms are pronated, the body is often shaken, and sometimes even raised from the bed in the violence of the convulsion. The eyeballs roll, and the head is turned to one or the other side convulsively. The lower jaw is moved forward and downward, and laterally; the tongue is sometimes caught between the teeth and bitten; there are swallowing movements performed by the larynx and pharynx; even the diaphragm may take part in these clonic convulsions, giving rise to hiccough which Soltmann considers a very dangerous symptom. Consciousness is entirely abolished, the conjunctivæ can be touched without the patient wincing. During this stage the sphincters may become relaxed, so that there is involuntary passage of fæces and urine. The respiration is stertorous, the pulse frequent and intermittent. The temperature is elevated during the convulsion, even when the spasm is of non-febrile origin; in that case, however, it subsides very rapidly, which is not the case in febrile eclampsia. The clonic convulsions may last from a minute to half an hour. In this respect attacks of eclampsia differ from those of epilepsy, which, as a rule, are not of long duration. The convulsions gradually diminish in severity until they cease, although convulsive movements may still remain localized in some muscles of the face or upper extremities long after they have ceased in other portions of the body. The patients return to consciousness gradually; they are at first irritable, soon they become drowsy, and frequently fall asleep. Such is a general description of an ordinary eclamptic seizure. This single attack is followed in many cases by a repetition, either shortly after the first convulsion or at a longer interval depending upon the etiology. If the convulsion is of the febrile variety, the reduction of temperature will generally cause a cessation of the spasm; should it belong, on the other hand, to the toxic or reflex group of convulsions, the frequency will depend upon our success in combating the etiological factor. When the patient falls from one convulsion into another, giving rise to a series of convulsions, he may be said to be in a condition analogous to the status epilepticus. Such a status may continue for days. Eclampsia, as well as epilepsy, may be very slight, consisting chiefly of a brief period of rigidity followed by little or no clonic spasm. There may even be nothing but slight paleness, accompanied by momentary loss of consciousness, and almost immediate recovery. These slight attacks, however, are not so frequent in eclampsia as in epilepsy (petit mal). Localized spasm, well defined in character and unaccompanied by loss of consciousness, cannot be regarded as eclamptic; thus a spasm of one arm or one leg, or of one side of the face alone, even with loss of consciousness, especially if repeated, would point to a local cerebral disease, and therefore cannot be classed in the group of eclampsia, but belongs rather to the class of localized epilepsies.

Laryngismus Stridulus.—The condition known as laryngismus stridulus, of which we have already spoken, while eclamptic in character is peculiar when considered as a convulsion. Cases differ from each other in severity to a very marked extent. In mild cases, the attack, occurring in children affected by active rachitis, consists of the sudden onset of a peculiar crowing respiration, repeated several times. The child turns pale, a look of dread overspreads the countenance, the loud crowing respiration becomes very rapid, the expiratory efforts being very short, the inspiration loud, crowing and whooping in character. There is generally, however, no cough after inspiration as in whooping-cough—the face becomes cyanotic, consciousness is not totally lost. The patient very suddenly regains his normal condition. Such an attack may last from a few seconds to a minute or two.

A second class of cases are of a severe character. There are sudden paleness and total stoppage of respiration, followed by phenomena similar to those described in the milder attacks. In a third group of cases the spasm of the glottis, initiated as in the first and second classes, is so severe and long in duration that the patient is temporarily asphyxiated. The face and body are cyanotic; the pupils, at first contracted, become dilated; opisthotonos, with some spasms of the whole body and extremities, is in turn followed by clonic spasm and the other phenomena of an attack of a more or less general eclampsia. Such attacks of laryngismus stridulus, however frequent they may be, generally diminish both in severity and in number, as the rachitic disease is diminished and cured. Even in the worst attacks the eclamptic attack is generally followed by the sleep of exhaustion and the patient wakes up in a normal condition. Death from asphyxia very rarely occurs. This, however, does occasionally happen and sometimes in cases in which the attacks have been very mild. The frequency of the attacks varies, some patients having very few, one every four or five days, others one a day or night, while some have as many as forty or fifty attacks of greater or less severity in the course of a day. The severity of the laryngospasm varies with the severity of the auto-intoxication of the particular case. The attacks are generally initiated by some irritation or excitement, by overloading of the stomach or bowels with food, by draughts, by cold water, by fright, indeed by any external irritation.

SEQUELÆ.—Although in the large majority of eclamptic attacks, of which the patients do not die, recovery is complete, leaving absolutely no sequelæ, the text-books relate a large number of possible injurious effects from eclampsia infantum. A fatal result is far more frequent in these seizures than is generally supposed. Dr. West, in his work on "Diseases of Children," showed that in London the proportion of deaths from convulsions in children under one year, as compared with deaths from other causes, was twenty-one and nine-tenths per cent.; from one to three years, about four per cent.; and from three to five years, about three per cent. Other authorities also agree that eclampsia is the most fatal condition to which children under one year are subject. It is almost impossible, however, to estimate what proportion of infants thus attacked die, since only fatal cases are reported in official statistics, while private statistics are neither sufficiently numerous nor sufficiently trustworthy to be reliable. Of children who recover, many are subject to repeated attacks, even under slight or no provocation, and it becomes a question as to whether the eclampsia so called has not turned into chronic epilepsy. Among the authorities who favor the view that chronic epilepsy is often the result of repeated attacks of eclampsia are R. Demme[15] and E. C. Seguin.[16] It does not seem at all improbable that a frequently repeated convulsion may so disturb the equilibrium of the nervous centres as to render these liable to initiate a convulsion, even under slight provocation, finally terminating in confirmed epilepsy. It is more probable, however, that the cases in which a so-called tendency to eclampsia finally terminates in epilepsy are really at the start epileptic. Some conditions frequently known to give rise to eclampsia may have been present at the time of the first attack, and a diagnosis of eclampsia may have been hastily made; such cases will be cleared up, later on, by the more or less frequent recurrence of the attacks without any cause.

Some of the more immediate sequelæ of an eclamptic seizure are ecchymoses under the skin and conjunctiva. These hemorrhages appear to be the result of the venous congestion which accompanied the tonic spasm at the onset. The violence of the clonic spasm may be so great as to tear muscular fibres or tendons, or even produce dislocations. Indeed, a case has been reported in which a fracture of the sternum was caused by the violent contractions of the rectus abdominis. Temporary paralysis of individual muscles or muscle groups often results from an attack of eclampsia; this seems to be only functional, however, for in a few hours or days power returns, and no trace of the paralysis is left. Temporary contractures may remain in the muscles that have been the seat of the greatest convulsions; thus wry-neck and various contractures have been observed to follow an attack of eclampsia. I recall a case in which the fingers of both hands remained contracted into the palm of the hand for two days after an eclamptic convulsion; but in a short time the patient recovered full use of his hands. I cannot agree, however, with those who claim that a simple attack of eclampsia, not connected with any lesion of the nervous centres, is capable of producing permanent paralysis or contracture. When a monoplegia or hemiplegia seems to result from an attack of eclampsia, I feel convinced that a careful clinical examination will point to the suspicion that the convulsion was the result of a lesion of the nerve centres resulting in convulsions, rather than that the eclampsia had resulted in the paralysis. It is claimed by those who hold the latter view that these paralyses are the result of meningeal hemorrhages over the motor area of the cortex of the brain as a result of the convulsion. It is possible that a monoplegia could occur in this manner, for even a very slight hemorrhage would be sufficient to affect the functions of a limited area of the cortex. A hemiplegia, however, produced in this manner would necessitate the presence of a clot sufficiently large to interfere with the whole of the motor area of one hemisphere; that such a hemorrhage should occur as a result of an attack of eclampsia is scarcely conceivable. Some common congenital deformities, such as club-foot, for instance, have been ascribed to attacks of eclampsia occurring in fœtal life, and resulting in contractures of the muscles, and thus in club-foot, contractured knees, etc. A careful study of these deformities will generally reveal their true etiology.[17] I am disposed to consider all cases of permanent paralysis or contracture (primary or secondary) in children the result of a lesion of the nervous centres, of which the convulsion was only a symptom; in such cases there will generally be found some more rational method of accounting for the production of the paralysis than that which refers it to meningeal hemorrhage as a result of eclampsia.

DIAGNOSIS.—Eclampsia may be confounded with epilepsy, and with convulsions due to disease of the nervous centres. From epilepsy it can be distinguished by a careful examination into the previous history. The older the child, the more often the convulsions have occurred without any recognizable cause, the more probable becomes the diagnosis of epilepsy. In this connection it must not be forgotten that attacks that were originally eclamptic may, after a time, when the convulsive habit has been acquired, become epileptic. Such children must be carefully watched, and should any suspicion of the presence of chronic epilepsy arise, the patient must be treated accordingly.

As far as the attack of eclampsia itself is concerned, there is no way of distinguishing it from an ordinary attack of epilepsy. Convulsions due to disease of the nervous centres have certain peculiarities which distinguish them from ordinary attacks of eclampsia. One important characteristic is that these convulsions are apt to be localized, especially if due to chronic brain disease; lesions of the various motor centres will give rise to convulsions limited to portions of the body supplied with nerve force from these centres. In acute diseases of the brain and spinal cord, and the meninges, there will be other symptoms which will lead to a diagnosis of the disease, of which the convulsion is only one of several manifestations. A differential diagnosis of the different varieties of eclampsia infantum will depend upon a careful physical examination of the patient. If there be fever or toxæmia, they should be recognized together with the diseases which have produced them. If the convulsion appears to be due to neither of these causes, we should carefully search for some possible peripheral irritant, and, if possible, remove it. Accuracy of diagnosis is apt to depend in these cases upon the broadness of our knowledge of diseases and conditions of infancy. To attempt to treat a case of eclampsia infantum without at least an attempt at an etiological diagnosis, is to submit the patient to the most injurious form of empiricism. The convulsion is a symptom of a disease which the physician must detect. We must search for the pneumonia, the diphtheria, the scarlet fever, the cause, and treat that at the same time that we treat the symptom. From tetany, eclamptic attacks can be distinguished first by the absence of loss of consciousness in tetany and the presence in the latter condition of drowsiness. The presence of Trousseau's symptom will also serve to distinguish the cases of tetany. This consists in the observation by the clinician that in tetany an attack of spasm can be produced by compressing with the fingers the point of emergence of motor nerves from bony canals. The differential diagnosis from hysteria is hardly a factor in young children. Laryngismus stridulus can be differentiated from whooping-cough by the character of the attack and the absence of the short, broken, and rapid cough which follows the long-drawn inspiration of whooping-cough.

PATHOLOGY.—Eclampsia infantum, being rather a symptom than a disease, has no pathology. It is true that morbid changes have been found in the nerve centres of children who have died of an attack of so-called eclampsia, but the mere fact that these changes were found precludes the diagnosis of eclampsia, which is essentially a convulsion that does not result from any grave lesion of the nervous centres. It is possible that repeated attacks of eclampsia result in subtle changes in the nerve centres, but if this be the case the changes are not discoverable by any method of examination practised in the present stage of pathological investigation.

Concerning the physiological mechanism by which an attack of eclampsia is produced, it will be proper to say a few words. The subject belongs of right under the head of epilepsy, as it is in connection with epileptic convulsions that it has been more thoroughly studied. Clinically, we have already stated, the eclamptic paroxysm in no way differs from an epileptic attack. The mechanism by which the latter is produced is stated by Reynolds,[18] in his "System of Medicine," as follows:

"The derangement consists in an increased and perverted readiness of action of these organs (medulla and vaso-motor system of nerves), the result of such action being the induction of spasm in the contractile fibres of the vessels supplying the brain, and in those of the muscles of the face, pharynx, larynx, respiratory apparatus, and limbs generally. By contraction of the vessels the brain is deprived of blood and consciousness is arrested; the face is or may be deprived of blood, and there is pallor; by contraction of the muscles which have been mentioned there is arrest of respiration, the chest walls are fixed, and the other phenomena of the first stage of the attack are brought about.

"The arrest of breathing leads to the special convulsions of asphyxia, and the amount of these is in direct proportion to the perfection and continuance of the asphyxia.

"The subsequent phenomena are those of poisoned blood, *i.e.*, of blood poisoned by the retention of carbonic acid, and altered by the absence of a due amount of oxygen."

These are practically the views held by Kussmaul and Schroeder van der Kolk,[3] as to the manner in which a paroxysm is produced; the causes of the primary derangement of the nervous centres will vary with the cause of the convulsions: in one case it is elevated temperature, in another toxæmia, in a third a peripheral nervous irritation, and finally the changes and phenomena due to rachitis.

As I have already stated, only such cases of rachitic eclampsia as are due to a toxæmia depending upon auto-intoxication and the special cases, already considered, of laryngeal spasm, are properly eclampsias. Convulsions due to gross lesions of the brain and of the cranial bones cannot be regarded as eclampsias but rather as symptomatic epilepsies. Thus, for instance, the condition of the skull, known as craniotabes, so frequent in rickets of very young children, renders the brain very much subject to external pressure owing to the pliability of the cranial bones. Convulsions due to such pressure over the motor cortex of the brain are localized epilepsies due to craniotabes. Convulsions of a general character due to hydrocephalus, which is one of the results of rickets, would also be excluded from functional eclampsias, being due to an organic brain lesion. Osteophytic hypertrophies of the inner tables of the skull, causing localized pressure over the brain structure, especially over the motor areas of the cortex, might produce convulsions which would be of the Jacksonian type and not eclampsias, such as we here consider. The general convulsions, however, due to the blood changes resulting from the auto-infection of rickets, as well as such as result from the chlorotic condition of the blood (lower percentage of hæmoglobin, diminished red blood globules) found in rickets, and those due to febrile, reflex, or toxic causes, slight in character and yet producing convulsions owing to the more than usually excited irritability of the nervous centres in rachitic children, such convulsions are of right classed as rachitic eclampsia.

As to why convulsions occur in febrile eclampsia is best understood by discussing some important points in the pathology of fever. Fever itself is a nervous phenomenon, the effect of a primary derangement of the nervous system. Normal temperature is dependent upon the maintenance of a proper proportion between heat loss and heat production. The mechanism which controls this proportion resides in the central nervous system. In fever this mechanism is disturbed. Observers have sought to localize the portion of the nervous system in which this mechanism resides. There is a large literature upon this subject, and although much work must yet be done before we shall know as much of the localization of heat centres as we do of motor-nerve centres, or of the origin, course, and distribution of thermic nerve tracts as we do of motor tracts, yet this much has certainly been established that the heat function of the body is under the control of large nervous centres chiefly located in the brain and probably distinct from the motor centres. The thermic nerve tracts, although separate in the brain from the motor-nerve tracts, are closely connected with the latter at the medulla oblongata.

It would appear, then, that an attack of eclampsia, occurring in the course or at the outset of a disease of such a character that the accompanying elevated temperature is apparently the causative element, so far as the convulsion is concerned, calls into activity two sets of nerve centres—the thermogenic centre or centres, and the convulsive centre or centres.

Hughlings Jackson has shown that what he calls a "discharging lesion" of any portion of the brain may initiate the action of the medulla as a convulsive centre. We do not know the nature of such a "discharging lesion": it leaves no trace which can be demonstrated at the post-mortem table. It may be excessive hyperæmia, or anæmia, or some minute change in structure. We have no means at present of demonstrating the lesion. A similar alteration or lesion occurs in the thermogenic centre. Its effect is fever or rise of temperature; secondarily, it throws into activity the unstable convulsive centre, if I may so term it, in the medulla, especially in infants, in whom, as has been seen, the medulla, together with the motor centres, is in an exalted state of irritation. Furthermore, it is probable that, in the medulla, the motor and thermic nerves are intermingled. What more natural than that an irritation of the one results in an irritation of the other? Of the probable correctness of this hypothesis we have, however, another proof. The same reasons that would lead us to expect that the irritation of the fever centres should, in proper subjects, cause an irritation of the convulsive centre would also presuppose the possibility of a reversal of this process. In other words, we should expect the activity of the convulsive centre to produce a secondary activity of the fever centre. This is certainly fully demonstrated by practical experience at the bedside. All authorities are agreed as to the enormous rise of temperature which occurs in the course of a so-called "status epilepticus." The epileptic falls into convulsions, repeated at very short intervals, so that the patient does not recover consciousness for hours, or even days. Shortly after this condition has set in the temperature begins to rise, and sometimes reaches an enormous height. Bourneville has seen it as high as 107½° F.; Reynolds reports equally high temperatures.[19]

PROGNOSIS.—The prognosis of an attack of eclampsia resolves itself into two elements: first, as to the fatal or non-fatal termination of any attack, and secondly, as to the recurrence of the convulsion. Although many infants die in an attack of eclampsia, yet, when we consider the great frequency of such attacks, those that die are comparatively few in number. The prognosis in this respect does not depend upon the severity of the seizure; very severe convulsions will often last but a short time and terminate in complete recovery. The duration of an attack of eclampsia is a more important factor in the prognosis. A series of convulsions of long duration, with short intervals between the individual attacks, renders the prognosis grave; and yet children sometimes recover after lying in "status convulsivus" for one or two days. Convulsions in which one side appears to be far more affected than the other are much more apt to be fatal than those in which the difference between the two sides is not so marked. A fatal termination, as well as a repetition of attacks of eclampsia, will often depend upon our inability to remove the cause which lies at the root of the derangement of the nervous centres. An attack of eclampsia may be repeated either within a short time after the original attack, and is then probably due to the same cause as the original convulsion; or after the lapse of weeks and months, and must then be studied with reference to its etiology as an entirely new seizure. If after an eclamptic seizure a child recovers completely and returns to its normal condition, and especially if the cause of the convulsion has been surmised and removed, the prognosis is good, the convulsion will probably not recur; it is best, however, even in these cases, to be guarded and prepare the patient and friends for a recurrence, rather than the contrary. In the large majority of cases, however, and above all in those cases in which the cause of the convulsion cannot be removed or is unknown, the convulsion is apt to be repeated; the more frequently the convulsion is repeated during a limited period of time, the more unfavorable the prognosis as to recovery. The convulsions are more apt to be multiple in the peripheral and toxic variety of eclampsia than in the febrile. The reason of this is obvious, inasmuch as fever is a condition which, temporarily at least, may be removed, while the former two do not so readily admit of treatment. A child that has already had attacks of eclampsia is far more liable to repeated returns of convulsions, under the influence of proper exciting causes, than one that has never had a convulsion. In the former case the nervous system has already shown its instability, and hence our distrust. In conclusion I would repeat, the prognosis depends to a great extent upon our ability to recognize and treat the cause. In rachitic eclampsia, while the rachitic disease is on the increase, the liability to eclampsia is on the increase. When the rachitis is cured, the eclamptic attacks as a rule no longer recur.

TREATMENT.—In discussing the treatment of eclampsia infantum, we would repeat what has been urged concerning the necessity of a careful differential diagnosis as to the etiology of the convulsion. We should distinguish whether the convulsion belongs to the febrile, the toxic, or the peripheral group of convulsions. If it belongs to the former, the abnormally elevated temperature should be reduced as speedily as possible. For this purpose rapid and certain means should be employed. Cold sheets, sponging with equal parts of cold water and alcohol dilutus, cold baths, Ziemssen's baths—all of these are excellent methods of reducing the temperrature by external means, and our choice should be governed by general principles. Among antipyretic drugs, the best, most trustworthy, and most rapid antipyretic is antipyrin, in proper doses and at proper intervals. I am accustomed to give to children, a year old, gr. v. every hour until two doses have been taken, and to repeat the dose in six hours if the temperature shows a tendency to rise again. The object being to reduce temperature, the drug must be used in sufficient quantity to effect our purpose. If the convulsion be of the toxic variety, the indication is as far as possible to get rid of, or diminish, the toxæmia of the blood; the kidneys, the bowels, and the skin, all the excretory channels, should be brought into play. An enema, together with a cathartic, should be administered; a mustard bath should be given to produce sweating and to make the skin act vicariously for the kidneys; should these organs be at fault diuretics should be administered if not contraindicated by the general disease. Should the convulsion depend upon a peripheral irritant, it must, if possible, be removed. If the stomach be overloaded, an emetic should be administered; if constipation appears to be the cause, the bowels must be emptied. If dentition is the cause, and the gums are swollen, lancing is indicated; the swelling will thus be diminished, the teeth will be more easily cut through, and the irritation removed; if helminthiasis is at the root of the evil it must be treated. Whatever the peripheral irritant may be, it should be removed. There will be many cases that cannot be classified, which must be treated on general principles. In addition to treating the etiological element in any attack of eclampsia, it has been the custom of physicians to administer a class of drugs known as antispasmodics. The most important of these are the bromides and chloral hydrate, and during the convulsions amyl nitrite and chloroform. The bromides should be given in comparatively large doses to produce a beneficial effect. Thus, I am accustomed to give gr. vi. to gr. viij. every three hours to children one or two years old; even larger doses should be given if necessary until the convulsions cease and sleep is produced. Chloral hydrate may be used in small doses, either alone or in combination with the bromides. I have used the amyl nitrite, a few drops inhaled from a handkerchief during the convulsions, with but little success; I have been unable to convince myself of its utility when thus presented to infants. Should the convulsions be very severe and continue for a long time, chloroforming the little patient may be tried, although in cases severe enough to require this measure the convulsions are apt to return as soon as the effect of the chloroform passes away. In cases in which the bromides must be administered during a convulsion, it is best either to inject the drug per rectum or subcutaneously in solution. When given by the rectum the dose should be at least twice as large. I have always considered the application of cold cloths or ice-bags to the scalp as superfluous in ordinary eclampsia; if they accomplish any good at all it is only in cases in which reduction of temperature is an element in the treatment, and in these cases we have more effective means for accomplishing this result.

For the attack Trousseau advised compression of the carotids, either one or both, until the convulsions subsided. The carotids are compressed opposite the thyroid cartilages, by pressing the artery against the spinal column. The corresponding side of the face thereupon becomes pale and then cyanotic. In most cases the convulsive movements gradually cease and the patient falls asleep. Should the convulsion not cease the compression must be stopped as soon as the cyanosis is extreme. The compression may be repeated at quarter- to half-hour intervals; should it then not succeed in checking the convulsions we should not advise its repetition. In conclusion, it must not be forgotten that, whatever may be the disease of which the convulsion is a symptom, our attention must be mainly directed to the treatment of it, and not to the treatment of the convulsion alone.

Henry W. Berg.

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ECPHYMA GLOBULUS.—A name given to a contagious skin disease that manifested itself in Ireland during the famine years of 1847–48 and called by the Irish peasantry "Button Scurvy." Frazer, who described the disease, thought that it resembled frambœsia or yaws of the West Indies. It seems practically to have died out. The eruption, according to Frazer, occurred on any part of the body except the hands and feet, the lesions starting as slight elevations or tubercles. In this stage the skin over the lesions is perfectly normal. Increasing slowly in size the tubercles become discolored, gradually soften, finally forming prominent deep-red tumors looking like raspberries though considerably larger. These persist for an indefinite length of time unless treated, but the free use of nitrate of silver causes them soon to heal.

Charles Townshend Dade.

ECTHYMA.—This form of pustulosis of the skin is not, strictly speaking, a disease separate and distinct. It is rather a secondary or consecutive lesion occurring in many and varied disorders, in which the clinical type remains fairly constant. A predilection is displayed in most cases for the extremities, the lower in particular, but the trunk and neck are often attacked.

In the beginning there is a small pustule which generally takes a rounded outline, although the character of the local injury may give it an unusual appearance; for example, linear in infected scratch marks. When fully developed, the pustule, tense or flaccid, is seated on an indurated base whose redness fades gradually into the surrounding skin. The purulent contents soon dry into a thick, dark crust, adherent, and showing on removal a superficial ulceration of the corium. The base of the ulcer is uneven, due to indolent granulation tissue and of a red or grayish color from the presence of pus. In syphilis, the crust of ecthyma becomes stratified (rupial) like the shells of crustacea, due to spreading of the lesion under its dried cover. The ulcer heals slowly and with the formation of a small scar, which is always evident when the patient is afterward stripped for examination. Development is rather slow, but the individual pustule usually runs its course in a fortnight. It may be single or be accompanied by others, developed either coincidentally or appearing in successive crops. Subjective symptoms are those of burning and pain; itching, if present, is due to previous disease.

Ecthyma gangrænosum may be separated from the mass of ecthyma and given a definite place on account of its etiology and its occurrence in young, cachectic children. The lesions are apt to appear on the buttocks, thighs, and perineum and are extremely indolent. The ulcers are of a deep red color and covered by a dirty, tenacious slough, varying in size up to that of a silver quarter of a dollar. The earliest lesion observed is a brown or dark-red discoloration, which soon becomes necrotic. In Kreibich's case there were twenty-five or thirty ulcers at one time.

Etiology.—As in other conditions, especially those of a purulent character, three factors determine an outbreak of ecthyma: first, a depraved state of health, second, a point of entrance of diminished resistance for (third) the invading organism. The disease attacks all ages and both sexes, but is more common in adult males. Lowered vitality may simply, as in vagabonds, result from insufficient nourishment, but it may be a part of infections like syphilis and tuberculosis (scrofuloderms of Duhring), or of diabetes, Bright's disease, and anæmia. The injury to the tissues is most often due to scratching commonly of louse, bedbug, and flea bites, but also in the course of the pruritus of eczema, diabetes, dermatitis herpetiformis, and senile pruritus. Localization of specific morbid products furnishes a portal of entry doubtless in the granulomata, syphilis, and tuberculosis. The invading organism is in most cases the streptococcus, inoculated by dirty finger nails, clothes, and bedclothes The other pus cocci of course may be present. The Bacillus pyocyaneus seems to be responsible for ecthyma gangrænosum—I say seems, because it is quite possible that it is inoculated in ulcers perhaps due to another organism, from alvine discharges. At any rate, it has been regularly found by such men as Ehlers, Baginsky, and Kreibich. The infants are invariably cachectic.

Histopathology.—The pathological process begins in the corium in the form of a circumscribed area of purulent inflammation. The cellular infiltration is chiefly of polynuclear leucocytes, the vessels are dilated and congested, and the tissue elements at the periphery are separated by a serous exudate. Later, a central necrosis occurs with complete solution of fibres, vessels, and skin appendages in its area. The epithelium covering the pus collection is much swollen, owing to an intracellular as well as an intercellular œdema. Many of the cells show hydropic degeneration. By specific staining, a network of fibrin can be demonstrated at the centre. The crust is composed of fibrin filaments in whose meshes are entangled epithelial cells and leucocytes; when it separates there is left an ulceration which extends into the cutis and which heals by the usual process of granulation and scar formation. Slight pigmentation may persist for a little time.

Diagnosis.—Differentiation of ecthyma from other pyodermias is a matter of small importance as compared with recognition of the underlying condition. Impetigo contagiosa is superficial with a "stuck-on" crust which leaves on removal no ulceration; pustular eczema is a diffuse process with no epidermal destruction; furuncles show unmistakable necrotic plugs. The ecthyma of syphilis has an indurated base, its crust commonly takes on a rupial character, and the ulceration is apt to be characteristically reniform. In the absence of external factors, careful search for a causative systemic condition—such as anæmia, cachexia, and, too often, starvation—must be made. When the skin shows excoriations and no pediculi or other parasites are to be found, it becomes necessary to decide which of the itching dermatoses is at fault,—an eczema, an urticaria, a pruritus, or a dermatitis herpetiformis.

Prognosis.—The outlook is invariably good so far as ecthyma itself is concerned, but on recovery from the pyodermic condition the prognosis becomes that of the causative, underlying disease. Ecthyma gangrænosum is always a grave condition, merely, however, as a sign of deep systemic depression.

Treatment.—Soap and water, good food and tonics constitute all that is really necessary. Even the pustular syphiloderm and scrofuloderm will get well with them alone, but the cure may, it is hardly necessary to remark, be hastened by appropriate local measures. In vagabonds' disease, the clothes and bedclothes should be boiled to kill lice and, if possible, the patient should be changed to a clean bed. After a preliminary bath, the crusts may be softened by sweet oil, boric-acid poultices or ointment, and removed. The bases of the ulcers are cleaned with hydrogen peroxide and covered by antiseptic surgical dressings. Gauze soaked in fifty-per-cent. ichthyol in watery solution is admirable for the purpose since it never starts a dermatitis of its own. The solid stick of silver nitrate is used to restrain exuberant granulations. In dispensary practice where elaborate dressings are usually out of the question, ecthyma heals readily under inunction with ten-per-cent. sulphur ointment, but its use must be stopped before it excites a reaction in the skin. Treatment of underlying cachexias must be left for consideration in their proper places.

James C. Johnston.

ECTODERM.—The ectoderm is the outermost layer of cells in the embryo, or outer germ layer. It is called ectoblast by some German, and epiblast by some English writers. The cells early arrange themselves so as to form a distinct epithelium; in the median line of the embryo the cells become thickened and give rise to the so-called medullary groove, out of which the nervous system is developed, these median cells becoming entirely separated from the rest of the ectoderm, which thus becomes the embryonic epidermis. The epidermal ectoderm develops all the epidermal structures of the adult, and also gives rise to the epithelium of the auditory labyrinth and to the lens of the eye, as described in the special embryological articles.

Charles S. Minot.

ECZEMA.—(Synonyms: Ger., *Eczem;* Fr., *Eczéma;* Tetter; Salt rheum.)

Definition.—Eczema is an acute or chronic inflammatory disease, presenting a most varied assortment of cutaneous lesions, and accompanied by more or less intense itching, burning, or pain. The lesions consist, at first, of erythema, papules, vesicles, or pustules, which may subsequently form into crusts or weeping surfaces, or infiltrated and scaly patches.

General Symptomatology.—All eczemas possess certain characteristics and are associated with definite general symptoms which may be briefly referred to before taking up the study of the disease in its various phases. Eczema is distinctly an inflammatory affection, and as such manifests, in some degree or modification, the cardinal symptoms of that process. These are: (1) congestion, with swelling and increase of local temperature; (2) fluid exudation into the tissues, with the formation of vesicles and pustules, or with a discharge upon the surface, resulting in crusts and scales; (3) plastic exudation, producing papules, patches of infiltration, and thickening; and (4) subjective sensations of itching, smarting, or burning pain.

The character and intensity of these various symptoms will depend upon the acuteness or chronicity of the inflammation, upon the locality affected or the extent of territory involved, upon the inherent temperament or peculiarities of the individual, and upon his habits of diet, the nature of his occupation, etc.

(1) *Erythema.*—The erythema may vary from the bright red blush which is seen in the acute forms of the disease to the dull redness commonly observed in the more chronic erythematous varieties. The amount of swelling accompanying it is a varying quantity, dependent generally upon the acuteness of the inflammation. An increase of local temperature is always appreciable, more marked in the acute than in the chronic forms, but is never a very decided symptom, such as that accompanying some other inflammatory affections, *e.g.*, erysipelas.

(2) *Serous Exudation.*—Exudation is a part of every eczematous process, the form of lesion produced thereby being determined by the various influences already enumerated. Fluid exudate will produce swelling, vesicles, and pustules, and when rupture occurs there will be a weeping, moist surface which dries into crusts and scales. The crusts are often thrown off rapidly, leaving a more or less continuously weeping or moist patch, or areas of greater or less extent. This discharge has the peculiarity of stiffening linen with which it comes in contact.

(3) *Plastic Exudation.*—When the exudation is plastic, papules and dry scaly patches result, the scales being either fine and branny or they become agglutinated into larger flakes, which are sometimes quite thick. The former are usually seen in the erythematous type of the disease, commonly found upon the face, or in the dry scaly eczema of the scalp; while the latter are observed chiefly in connection with chronic squamous eczema. Infiltration is present in every form of the disease, but it is only in the more chronic forms, where the exudation takes place deep in the corium, that the thickening and infiltration so characteristic of the disease are found. When not too great it can be fully appreciated by pinching alternately the healthy and the diseased skin; but in some inveterate cases the skin is so densely infiltrated that it cannot be pinched up. If it is so situated that the natural movements of the part subject the infiltrated skin to stretching, very painful fissures and excoriations are produced, which are often very difficult to heal.

(4) *Itching, etc.*—The subjective symptoms of eczema are perhaps the most important of any, both on account of the great distress they cause and the influence they exert in keeping up the disease. These symptoms vary greatly in the different cases and in the different forms of the disease, and even at different times in the same individual. In some cases there is merely a slight tingling or pricking sensation, or feeling of formication, while in the other extreme there may be most intense itching, which can be relieved only by deep and continuous scratching with the nails until a bleeding or oozing surface is produced. Between these two extremes various degrees of irritation are experienced. Sometimes, as in the acute and erythematous forms, smarting or burning is alone complained of. In other cases this amounts to a burning pain, without any itching or desire to scratch. The itching of eczema is, as a rule, paroxysmal or intermittent in character, aggravated generally by exposure to the air, and is invariably worse at night. Its character and intensity are likewise affected by the influences already mentioned, as having a bearing upon the general symptoms of eczema. Besides the itching or some of its modifications just enumerated, certain patients exhibit a most marked hyperæsthesia of the skin, particularly upon exposure to the air or the slightest contact of the clothing, and when certain remedies are applied to the skin.

In addition to the symptoms just described, certain characteristics in the course and evolution of the disease are common to all cases of eczema. The clinical picture varies from day to day, and in some cases, especially in children and infants, from hour to hour. Not only rapid changes in the severity of the process are to be expected, but the type of the eruption itself may change in a very short period of time. The reason for this will be apparent when we come to consider the various causes of the disease. Eczema either runs an acute course, remaining for a few weeks or a month when recovery takes place; or, as more commonly happens, it becomes chronic and may last for years or for a lifetime. It may be limited to only one region of the body or of an extremity, but more frequently it occurs in several localities, and generally in a symmetrical manner. Often the disease is more or less general in its distribution, and in rare instances it becomes universal. Its general tendency in every case is to progress, and spontaneous recovery is not to be looked for. No matter how severe or protracted the disease may be, there are usually no constitutional symptoms, although in the worst cases some impairment of the general health is manifested as a result of the persistent loss of sleep and prolonged suffering.

Eczema is so varied in its manifestations and so protean in character that to give a comprehensive clinical picture of the disease would obviously be impossible. It is necessary, therefore, in the further study of its symptomatology, to consider separately the various types of eruption which make up the symptom-complex of the affection. While this is essential for a clear understanding of the disease as a whole, it must not be forgotten that the several types about to be discussed rarely occur clinically in a distinct or pure form, but are often mingled one with another, or follow one another in rapid succession. This frequent and often very rapid change in the severity of the process and in the type of lesion has already been referred to as one of the chief characteristics of the disease.

For convenience of description the subject is divided in the following manner:

(A) Types of the eruption dependent upon the predominant, primary, anatomical lesion, namely, *eczema erythematosum, eczema papulosum, eczema vesiculosum*, and *eczema pustulosum.*

(B) Types dependent upon secondary changes in the preceding, namely, *eczema rubrum* or *madidans, eczema squamosum, eczema sclerosum, eczema verrucosum*, and *eczema fissum*, and

(C) Types dependent upon the stage or character of the inflammatory process, namely, *eczema acutum* and *eczema chronicum.*

The symptomatology, diagnosis, and treatment of the other special varieties of the disease, namely, eczema infantilis, eczema parasiticum, eczema seborrhoicum, and the regional forms of eczema will be considered separately.

A. Eczema Erythematosum.—This type of the disease occurs in its most characteristic form upon the face in middle-aged or elderly people, though it may affect any part of the body. It generally begins in small, irregularly shaped patches, of a more or less bright red color, which coalesce into larger areas. The face, however, may be acutely suffused, in which case there is considerable œdema, with closing of the lids and marked temporary disfigurement. When the affection is acute, after a few hours tiny vesicles develop upon the erythematous surface and some moisture or oozing is produced by the rubbing, which is resorted to in consequence of the itching. In the subacute form the color is a dull red, and slight scaling is to be observed, while in the chronic forms considerable thickening of the skin is produced, the natural lines being greatly exaggerated; the color in the more chronic forms varies from a dull red to a purple or brown and the scaling is more abundant. Itching and burning are the chief symptoms complained of, the former being so severe, especially when the disease is chronic, that the eyebrows are sometimes rubbed off in the efforts of the patient to obtain relief. The disease may be of very short duration, or may last for years, with intervals of slight improvement; this form is often spoken of as "*chronic erysipelas.*" Erythematous eczema of the extremities presents characters similar to those upon the face, though the scaling is apt to be more abundant, and here the type readily changes into the squamous form.

When it occurs upon the palms and soles the skin is thickened, red, and swollen, and is accompanied by most intense itching and burning. In the axillæ, beneath and between the breasts, or in the fold of the neck and groins in infants, the disease is of a brighter red color, and a moist oozing surface is produced. This form of eruption constitutes "*eczema intertrigo.*"

Eczema Papulosum.—The papular type of eczema is of very frequent occurrence, and is often one of the most obstinate forms met with. It is characterized by the appearance of firm, dull red, acuminate or rounded, raised papules, varying in size from a mere speck to that of a pin's head. These may develop in a discrete manner, scattered irregularly without tendency to grouping, over the part affected, or form here and there into small groups or even coalesce into patches. When located about the hair follicles a lichen-like appearance is presented, and on this account the disease was formerly called "*lichen simplex.*" The number of lesions present at any given time varies considerably. Often they are sparsely distributed, but after a time the itching becomes so intense that new papules develop rapidly in consequence of the severe scratching induced. These are soon capped by a small blood crust or are severely torn, so that serum oozes from their summits. There is perhaps no other variety of eczema in which the itching is such a marked feature.

The disease may remain papular throughout or the papules develop into small vesicles and then into pustules, or become associated with other vesicular or pustular lesions. When they are grouped, or become more or less confluent, weeping patches with infiltration and crusting may form as a result of vigorous scratching. Sometimes the lesions present the flat character of those seen in lichen planus, and the color being dull red or purplish, mistakes in diagnosis are not uncommon. This form of papule generally occurs about the neck and flexor surfaces of the wrists, both common sites for lichen planus.

The life history of any individual lesion or group of lesions is extremely variable. The same papule may remain almost unchanged for weeks or may disappear quickly, only to be replaced by others in rapid succession. Sometimes a single small patch or several patches, without any other manifestation, will affect some particular location and resist the most careful treatment for long periods of time.

The distribution of the eruption is of considerable importance, particularly as regards diagnosis. The trunk, especially the back and buttocks, and the flexor surfaces of the arms, forearms, thighs, and legs are the regions generally affected. It rarely occurs upon the face, hands, or feet. The disease is more common in adults than in children or infants, the liability being about the same for both sexes.

Eczema Vesiculosum.—Vesicular eczema pure and simple is perhaps less commonly observed than any other type of the disease. It is essentially an acute process and speedily changes into some other form, or is associated with some more chronic variety. . The attack is always preceded by tingling, pricking, or itching sensations, which are soon followed by a punctate or diffuse erythema, with more or less swelling of the tissues. After a few hours a number of tiny vesicles appear upon the reddened surface, which vary in size from a pin's point to a pin's head. These are pearly and transparent and have a very thin covering of epidermis. In some localities, as between the fingers and toes, and on their flexor surfaces, or on the palms and soles, which are the most common sites of the eruption, the erythematous stage is often wanting, the lesions appearing as minute transparent globules embedded in the skin. There is generally no tendency to grouping of the vesicles in this type of the disease, though they are closely packed together and sometimes even coalesce. In a very short time, even after the lapse of only a few hours, they either rupture spontaneously or are broken by the patient in scratching. Much relief from the itching is now experienced, but this symptom is quickly replaced by smarting or burning. The contents of the vesicles soon moisten the affected part, which is kept more or less wet by the oozing of serum from the vessels beneath, or is converted into a moist crusted patch. The serous crusts which form are of a characteristic yellowish color, and are never very thick. In some cases the crusts are continually washed away or are removed by contact with the clothing, leaving a red, angry, oozing surface, being thus converted into an "*eczema rubrum*" or "*eczema madidans.*" At other times the weeping diminishes and a scaly, red, infiltrated patch results, "*eczema squamosum.*" Under appropriate treatment, however, neither of these secondary forms develops, but resolution takes place by a gradual subsidence of all the symptoms. New vesicles cease to appear, the oozing becomes less and less, the surface heals beneath the crusts, and there is left a sensitive, slightly reddened skin, which in a few days becomes normal. Besides the secondary forms of eczema just referred to, into which the vesicular type of the eruption may develop, secondary inoculation frequently takes place with the production of a pustular eczema.

It must likewise be remembered that vesicular eczema is often associated with the other primary forms, appearing as an acute outbreak at some time during their course. In addition to the sites already mentioned, the disease may develop upon the face, on the flexor surfaces of the forearms and thighs, and less commonly upon various parts of the trunk; it is seldom, however, general in its distribution.

Eczema Pustulosum.—This type of the disease, which is sometimes called "*eczema impetiginosum*," usually begins in one of the preceding forms, the character of which is changed either by an increased intensity of the inflammation or by secondary infection by pus germs. It is possible for the eruption to develop *de novo*, but this is quite the exception. Any diseased condition or physiological state that will diminish the natural skin resistance against the incursion of pathogenic organisms predisposes to this form of eczema. It is therefore more common in infants, especially in the strumous and ill-nourished, and in elderly people. It is seen in its most characteristic form upon the head and face of infants, where from very early times it has been known as "*crusta lactea*," or the "*milk crust eruption*."

It generally begins in a group of papules or an erythematous patch, which speedily becomes moist and crusted from the subsequent development of vesicles. Infection soon takes place from the wounding of the surface by the nails, and thick greenish crusts form, which, when matted with the hair on the scalp, emit a most nauseous odor. It usually occurs symmetrically on both cheeks and around the ears, but in very bad cases may cover the entire head. In elderly people it is most frequently observed upon the lower legs, where it may affect only the region around the ankles or may cover the entire leg with thick, dirty greenish crusts.

Pustular eczema may also attack the bearded face and the hairy region of the thighs, in which case it must be differentiated from sycosis and folliculitis. Eczema, however, is never confined to the follicles, but also affects the intervening skin and often spreads to non-hairy parts.

The itching of pustular eczema is less marked than in some of the other varieties of the affection. Except in very rare instances, in which deep wounds have been made, this eruption is never followed by scarring or permanent loss of hair.

B. Eczema Rubrum or Eczema Madidans.—Eczema rubrum may develop from any of the preceding varieties, but, as already mentioned, most commonly follows vesicular or pustular eczema. It often results in consequence of improper treatment. The patient's occupation or his injudicious care of the eruption may likewise be responsible.

It is characterized by intensely red, inflammatory patches, or diffuse areas which continuously exude a clear serum that subsequently dries into brownish or green crusts of variable thickness. These in turn are loosened by the accumulation of serum beneath, or are forcibly removed by contact with the clothing, producing an intensely red, infiltrated, and continuously weeping surface. This constitutes one of the most distressing forms of eczema, as it is generally chronic in its course and the subjects of it suffer intense pain most of the time.

It is especially common upon the lower legs of elderly people and often covers the entire leg, accompanied by much œdema and great infiltration. It also occurs on other parts of the body, particularly in regions where there are heat and moisture, as in the axillæ, in the folds of the breasts, nates, etc.

Eczema Squamosum.—While in the preceding variety of eczema the peculiar clinical symptoms are due to the great intensity of the inflammatory process, in this, the squamous form, the acute catarrhal characters are in abeyance. By a subsidence of the discharge and a diminution in intensity of the inflammatory symptoms, eczema rubrum may subsequently become squamous eczema. It is more commonly, however, a sequel of eczema erythematosum, but is often an intermediate form occurring at some time during the involution of some of the other primary types. Papular eczema, by coalescence of the lesions, may likewise develop into this form of eruption. Squamous eczema generally appears in variously sized, irregularly outlined patches, some oval, some elongated, and when of long duration quite sharply defined. The color is a dull red, and there are always considerable infiltration and scaling.

The scales are not large and flaky and are not firmly attached as in psoriasis, but usually brush off quite readily.

When the affected skin is irritated by severe scratching, a weeping surface may result with the production of serous crusts, an event that is liable to occur in any form of eczema. The most common localities for squamous eczema are the scalp, face, and back of the neck. Patches of the disease are also frequently observed on the outer surfaces of the arms, on the extensor surfaces of the thighs and legs, and sometimes upon the trunk.

Eczema Sclerosum.—This clinical type is observed practically only upon the palms and soles. It begins as an ordinary eczema of these parts which becomes chronic and results in great thickening of the tissues. The epidermis presents a calloused appearance, and is often so hard and stiff that flexion of the hands or fingers is rendered impossible. In those who labor with their hands the disease is seen in its highest development. It simulates very closely the symmetrical keratoses, either hereditary or acquired, but is always readily distinguished by the fact of there being a pre-existing eczematous condition.

Eczema Verrucosum.—As the name implies, this is a warty form of eczema. Besides the induration and thickening there is papillary hypertrophy resulting in a rough, warty surface that bears very little resemblance to an eczema.

The most characteristic examples of verrucous eczema are seen upon the lower legs, where it sometimes attains such a high state of development as to resemble an elephantiasic condition. The natural contour of the limb is generally destroyed and the diseased surface emits a sickening odor from decomposing secretions retained in the deep sulci between the warty growths. This form of eczema occurs also in other localities, as in the axillæ, about the genitals, beneath pendulous breasts, etc., wherever, in fact, heat, moisture, and uncleanliness favor epidermic and papillary hypertrophy.

Eczema Fissum.—Any eczema affecting regions in which the skin, from its anatomical position, is subjected to more or less movement or stretching, is very prone to develop rhagades or fissures; this complication constitutes eczema fissum, or "*eczema rimosum*." The eczematous process renders the skin inelastic and it cracks very readily. These fissures may extend only through the epidermis, but generally they go much deeper, even penetrating the upper part of the corium. They are extremely painful, bleed very easily, and often last a long time, if so situated that the part cannot be immobilized. Fissures may complicate any of the primary forms of eczema, although the erythematous and papular types are more liable to develop these secondary changes. Eczema fissum is most commonly seen upon the palms of the hands and soles of the feet where it frequently results from an eczema sclerosum, upon the flexor surfaces and tips of the fingers, behind the ears, and in the flexures of the limbs. It is likewise often observed at the junction of the skin and mucous surfaces, as the corners of the mouth and around the anus.

The condition commonly known as *chaps* or *chapping* may or may not be associated with eczema. It very frequently occurs in those having delicate skins, but having no history of eczema nor tendency to that condition.

It results from the use of irritating soaps, excessive use of hot water, exposure to cold winds, etc.

C. ECZEMA ACUTUM and ECZEMA CHRONICUM.—This is a very important division of the subject, especially from a therapeutic standpoint. The term acute eczema refers both to the intensity or inflammatory character of the eruption and to its duration. We call an eczema acute when it begins suddenly with redness and swelling, accompanied by an itching, burning, or tingling sensation. It may appear in one or several localities, or may spread from one focus over an entire limb or large area of the body. It may remain an erythematous eczema or papules, vesicles, or pustules may develop, resulting in weeping patches or scaly and crusted areas. It often presents many characters of a simple dermatitis, but if the affected skin is carefully protected and treated by soothing remedies, the disease slowly subsides and the attack is of comparatively short duration. On the other hand, this same character of eruption may extend over long periods of time with alternating intervals of quiescence and acute exacerbation, so that while the disease in such cases may be justly called chronic, the eruption is always acute in character, and must be so considered in its therapeutic management.

Chronic eczema, clinically speaking, is characterized on the contrary by infiltration and thickening of the tissues, and generally occurs in the form of thickened, scaly, dull red patches or infiltrated areas of varied extent. It may affect any given locality as the scrotum, bend of the elbows and knees, etc., and may resist treatment for years; or it may become fairly universal, the entire skin being greatly thickened and scaly, the natural lines exaggerated, the whole of a dull red color, and imparting a distinct leathery sensation to the touch. The itching is often so intense that the hairs are rubbed off in efforts to obtain relief, or secondary changes take place as a result of the vigorous scratching to which the skin is subjected. Fissures and cracks, already referred to, are a common complication, as are also furuncles and ecthymatous lesions, and various secondary manifestations due to inoculation with pathogenic germs. The most stimulating and revulsive measures are often necessary in the treatment of the eruption in this stage. It must not be forgotten, however, that an eruption of an acute type may develop from time to time during the course of a chronic eczema, necessitating the employment of only the most soothing remedies.

Besides the acute and chronic stages of eczema, there is a subacute form which occupies both clinically and therapeutically an intermediate position. Very many of the cases which apply for treatment present an eruption of this character, but, with a clear knowledge of the clinical features of acute and chronic eczema, the physician will find no difficulty in recognizing the disease in its intervening stages.

PATHOLOGY.—The pathological changes in eczema are those of ordinary inflammation. That it is a catarrhal inflammation of the skin, similar to that affecting mucous membranes, is conceded to-day by most observers, and the pathological findings in the majority of cases certainly lend support to this view. Duhring, however, thinks we ought not to insist too strongly on this point, inasmuch as many of the manifestations of eczema differ from those observed on mucous membranes. The causes operative in the production of the skin changes are far from clear, in spite of the great advances made in cutaneous pathology during the past ten or fifteen years. There is, in the first place, something in the skin of an eczematous subject that renders it susceptible to the action of irritants of either local or internal origin. What this is we do not know, but presume it to be some nutritional defect. What the exciting cause is that sets up the inflammatory changes in this impaired or weakened skin is yet to be ascertained. Much has been done in recent years in the study of micro-organisms in connection with this disease, but it still remains unproven that any particular parasite is the exciting cause of eczema. On the other hand, it seems reasonable to believe, in the author's opinion, based upon the accepted teachings in general pathology, that the various micro-organisms found in eczema are rather the result of, than the cause of the local manifestations of the disease. It seems much more plausible, considering the varied etiology of eczema, and its dependence in most cases upon constitutional derangements of one form or another, to regard toxins circulating in the blood as a probable exciting factor in the production of the lesions.

Crocker is inclined to believe with Hebra and Tilbury Fox that eczema, when not due to local irritants, is a trophoneurosis, either central or peripheral. In support of this view are the cases in which inflammatory changes have been observed in the nerves supplying an eczematous patch.

PATHOLOGICAL ANATOMY.—The morbid anatomy of eczema, as already mentioned, is that of ordinary inflammation, consisting in hyperæmia, dilatation of the blood-vessels of the corium, exudation of serum resulting in œdematous swelling, and diapedesis of white blood cells.

There are also connective-tissue cell proliferation and degeneration of the rete cells. These changes vary according to the stage of the disease. In acute eczema the inflammation is diffuse except in the papular form, when it is more circumscribed. The primary changes are in the papillary layer, from which they extend to the epidermis, to the deeper parts of the corium, and in some cases even to the subcutaneous fatty tissue. They consist in blood-vessel dilatation, serous exudation, and diapedesis of the white corpuscles. The detritus resulting from the destruction or degeneration of the rete cells mingles with the serum to increase the œdema. Vesicles in acute eczema are situated in the upper part of the rete. The cells degenerate with the formation of spaces between the nucleus and protoplasm, which enlarge into a cavity containing serum, cell fragments, and fibrin. When the exudate is excessive, the horny layer is raised from the rete, forming bullæ or large vesicles.

If there is an extensive cell degeneration, the cavity of the vesicle is filled with leucocytes and is converted into a pustule; here pus organisms are always to be found. In eczema rubrum there is, instead of the formation of vesicles or bullæ, an entire removal of the horny layer, which, on account of deficient keratinization, is not restored, leaving the corium exposed. In acute papular eczema the changes are limited to a circumscribed area and, according to Robinson, take place primarily around the follicles, especially the hair follicles.

The morbid changes in chronic eczema consist in an hypertrophy of the rete, an enlargement and lengthening of the papillæ, and a thickening of the corium by an enormous proliferation of connective-tissue cells. In some cases the tissues may become so dense as to result in lymphatic obstruction and elephantiasic changes. The glandular structures, as well as the hair follicles, may become atrophied or even entirely destroyed in the more chronic forms of the disease.

ETIOLOGY.—Eczema constitutes in this country about one-third of all cutaneous affections. It is by far the most important disease of the skin which the general physician is called upon to treat. It affects men and women in about equal proportion and occurs at any age from the earliest weeks of life to old age. The greater number of cases are observed between the ages of twenty and forty, the period of greatest activity in most people's lives. The disease is never inherited in the true sense of the term, but, as in the case of so many other troubles, a tendency or predisposition to eczema may be inherited. In such the disease is readily lighted up, often by the most trivial agencies, that would not be deleterious in any way to most persons.

Eczema, as far as we know, is not a contagious disease, though certain forms are parasitic in nature; some of these latter are autoinoculable.

The causes of the disease may be conveniently arranged under two headings, those of *internal* or *constitutional origin*, and *external* or *local causes*. No single cause is ever responsible for a given attack of eczema, its etiology is distinctly a complex one, and while this division is made for the sake of convenience, it must be understood that the two classes of causative factors often act conjointly.

Constitutional Causes.—Eczema is a disease of debility; no healthy individual, in my opinion, ever suffered an attack of eczema. Even in those cases in which the disease is dependent upon local causes alone, there is always some constitutional defect which enables these causes to become operative. My views in regard to the nature of eczema conform, in a measure, to those held by Erasmus Wilson. He considered the disease one of *debility*, either "*assimilative*," "*nutritive*," or "*nervous.*" As far as it goes, this, I think, is the true conception of the nature of eczema.

Foremost among the constitutional causes of eczema are those dependent upon disorders of the gastro-intestinal tract. Dyspepsia in its various forms, constipated or irregular bowel action, intestinal and gastric flatulency, sluggish or disordered liver action, all these impair the general health and affect the nutrition of the skin. Improper and insufficient food, errors in diet, etc., while perhaps not affecting the gastric function, do debilitate the system and weaken the resisting power of the skin. In infants, these latter are the direct exciting causes of the eczema in a great majority of the cases, and are, therefore, of the very greatest importance in the management of infantile eczema. The ingestion of certain drugs, as arsenic, mercury, iodide of potassium, etc., is capable of bringing forth an eczema in certain individuals. I have only recently had under my care a case of generalized eczema due to the internal administration of mercury in the treatment of syphilis.

That there is a causative relation between the so-called gouty state and eczema there can be no question. The association of both rheumatism and gout with some form of eczematous disease is a matter of frequent observation. It is true that many sufferers from chronic gout or rheumatism never have eczema, but, *per contra*, these conditions are frequently observed to stand in a direct causative relation to the disease. Cases, for instance, have been observed in which an attack of constitutional gout has been relieved immediately upon the outbreak of an eczema, and patients remain free as long as the eczema lasts. It is also interesting to note the frequency with which we find a history of gout, rheumatism, chronic bronchitis, asthma, etc., in the antecedents of eczematous patients. In every eczema in middle-aged or elderly people the possibility of a gouty origin should be borne in mind.

Various disorders of the nervous system are potent factors in producing and keeping up an attack of eczema. This is not surprising when one considers the abundant nerve supply of the skin, the intricate and special termination of the nerve filaments and the very delicate mechanism which governs, through the vaso-motor nerves, the blood supply of this great organ. The most common condition observed in this connection is that of nervous exhaustion due to overwork, anxiety, excesses of various kinds, or direct shock of the nervous centres. Examples of neurotic eczema dependent upon one or another of these conditions are of very frequent observation. A recognition of the etiological relations in this class of cases is essential for the successful management of the disease.

The derangements of the nervous system in lithæmic subjects, as well as in those suffering from gastric, liver, or intestinal disturbances already referred to, deserve mention in this place. A train of nervous phenomena is sometimes engendered which reacts upon the original disorder, and thus a vicious circle may be established which is a powerful factor in causing or aggravating an existing eczema. Among other disorders of the nervous system may be mentioned direct injury to the nerves themselves, and also neuritis and some neuralgias. These have all been directly responsible for an eczematous outbreak.

Besides the causes just enumerated certain physiological states and functional or organic disease of remote organs may cause eczema through the influence of the reflexes. Among these may be mentioned pregnancy, lactation, the climacteric, dentition, retained smegma, misplacements, tumors or congestions of the uterus, movable kidney, etc. The intimate relation between asthma and eczema in certain instances has been noted by a number of observers. The two may coexist in the same individual or eczema may alternate with the asthmatic paroxysms. It is not known what the true relation is between them, but their association is frequently enough observed to warrant mention. An interesting instance of this came under my own observation. The mother of a family of four children, two sons and two daughters, suffered from asthma and eczema. One of the children (the eldest son) was also a subject of both asthma and eczema, and his daughter, an only child, was hopelessly crippled in consequence of an inveterate asthma, and she was likewise a sufferer from eczema. Diabetes may also be considered a cause of eczema. An eczematous eruption frequently develops about the genitals in diabetic subjects, but in many cases this disappears upon removing the sugar from the urine. In these cases the eruption would be more properly classed as a dermatitis. In a certain number, however, the eruption persists as an eczema and may develop elsewhere upon the body.

In concluding the consideration of the constitutional causes of eczema it is only necessary to mention that chlorosis, malaria, tuberculosis, or any systemic disorder which lowers the general nutrition, may stand in an etiological relation to the disease.

The doctrines of French authors attributing eczema and some other skin affections to the existence of certain diatheses, as the "*dartrous*," "*herpetic*," or "*arthritic*" diathesis, have few adherents at the present day.

Local Causes.—The agencies that may excite an eczema by their action externally upon the skin are exceedingly numerous and at the same time very important. Their actual position and importance as causative factors, however, are still a subject of considerable controversy. There are those, notably the pupils of the German school of dermatology, who regard them as the prime factors in the etiology of the disease, while other equally distinguished dermatologists consider them of altogether secondary importance. I believe that, for the successful treatment and management of eczema, it is essential to weigh fully every condition or agent that may stand in any way as a causative factor in the disease, whether of external or internal origin. I attribute very great importance to both classes of causes, for to be operative it is often necessary that they should act conjointly. I have already said that I did not believe a healthy person ever suffered from eczema; nevertheless, to call forth the disease an exciting cause is necessary, whether it acts from without or within the economy. Eczema is never engendered through the action of local causes alone, there is something else necessary, call it predisposition if you will, but there is, in my opinion, always some contributing factor which stamps the eczematous character upon the eruption thus excited.

It would not be possible to enumerate all the local causes of eczema. They usually comprise, however, three classes of agents, namely, those of a thermal, mechanical, or chemical nature.

The *thermal* agents, heat and cold, are sometimes important factors in the evolution of the disease. Both solar heat, either direct or reflected from water, and the artificial heat to which laundresses, cooks, stokers, firemen, etc., are subjected may be responsible. The first constitutes "*eczema solare*," and should be distinguished from erythema solare or sunburn which is a simple dermatitis. "*Eczema intertigo*," which develops in fat people and in infants through the action of heat upon moist surfaces, in the various folds of the body, must likewise be distinguished from erythema intertrigo. The action of cold in the production or aggravation of eczema is of common observation. This applies to climatic changes, including the action of cold winds, and to the contact of cold substances. Eczema is almost always worse in winter, and sudden changes from warm to cold may excite the disease or aggravate an existing eruption. I have had occasion to see a number of cases of eczema of the nails and surrounding tissues in ice-cream workers, who in the course of their work were compelled alternately to put their hands into very hot water and then into freezing mixtures.

Among the *mechanical* causes may be mentioned pressure and friction by either the clothing or such extraneous objects as trusses, braces, artificial limbs, etc., the dust and dirt incident to certain occupations, and traumatism of various kinds including scratching. Scratching is one of the most important of the local causes of eczema. There may be a pruritus as an early symptom of the disease or the itching may result from an urticaria, or from the bites of insects, such as fleas, pediculi, mosquitoes, itch-mites, bedbugs, etc. The prurigo of Hebra is often complicated by an eczema induced by scratching. Scratching will also invariably aggravate an existing eczema and cause it to spread rapidly.

Water used either too hot or too cold, as in the Turkish and Russian baths, is an exciting cause of eczema in a certain number of cases, and the washing of an eczematous surface almost invariably increases the trouble.

Vaccination will often cause the eruption to develop in one subject to the disease or having a predisposition to the same. I do not believe, however, that it is ever solely responsible for the disease, though it is generally regarded so by the laity.

The *chemical* agents that may produce eczema are very numerous, and only a few of them can be mentioned. The most common are the various acids and alkalies, strongly alkaline soaps, mercurial frictions, sulphur, arnica, alcohol, ether, chloroform, turpentine, iodine, iodoform, etc. The different dye stuffs and the various chemicals used in the trades are responsible for many of the so-called trade eczemas. Bricklayers, masons, printers, washerwomen, photographers, bleachers, dyers, and painters are often thus affected. Cooks and bakers may suffer from eczema caused by the action of the sugar, alum, borax, etc., used in making bread and pastry. Bartenders, waitresses and waiters, bottle-washers, and cigarmakers are another class who sometimes suffer from trade eczema. Exposure to the poison ivy, or *rhus toxicodendron*, and also to the poison oak, sumac, and some other poisonous plants will produce eczema in some individuals.

Animal and vegetable parasites may likewise be regarded as causes of eczema, and micro-organisms which are known to produce special types of skin lesions may possibly be responsible for some forms. Satisfactory proof, however, of the causative relation of any form of micro-organism to eczema has not yet been obtained.

Any one of the agents above-mentioned is capable of causing a skin eruption of greater or less severity. This may wholly subside upon removal of the cause and would then be regarded as an artificial dermatitis. In a certain number, however, the eruption persists and continues to spread and even develop in remote places long after the cause which excites it had ceased to operate. This latter is eczema, and any local irritant that acts in this way does so in a subject who is predisposed to the disease. The predisposition may be hereditary or acquired, but without it a true eczema will not be produced. One has only to study closely a few cases of trade eczema to be convinced of this. It is a very common thing in patients suffering from a severe eczema of this kind to hear them say that they have worked for years at the same trade, but never before had anything more than a slight irritation.

In summing up the causes of eczema it will readily be seen that the etiology of the disease is a very complex one. This would account for the rapid changes in the severity of the process and the great multiformity in the type of the lesions, as already referred to while considering the general symptomatology.

DIAGNOSIS.—The diagnosis of eczema is, as a rule, comparatively easy. The disease is so common that the ordinary types of the eruption are readily recognized by most physicians. I think the mistake of diagnosing some other affection as eczema is more often made than that of failing to recognize the disease when it is present. In some of the mixed forms, however, the diagnosis is often attended with the greatest difficulty, and even the expert is occasionally deceived in differentiating eczema from some of the rarer affections of the skin. It must also be remembered that eczema is often found associated with some other skin affection, and the greatest care is sometimes necessary in differentiating them.

The diagnosis of the special forms and local varieties will be considered when we come to study these later on. In this place the differential diagnosis will be made between eczema and the affections for which it is more liable to be mistaken.

Erysipelas.—This is an acute febrile disease, usually accompanied by severe constitutional symptoms; these alone will distinguish it from eczema. The disease begins at one point and spreads very rapidly, the area affected presenting a well-defined margin; the surface of the part thus affected has a shining, tense appearance, is reddened and swollen, and feels very hot to the touch. Eczema spreads more slowly, often begins at several points, is ill-defined, and the surface is roughened and scaly, very little swollen, and does not feel very hot. Pain and burning are complained of in erysipelas, while eczema generally itches. Vesicles may develop upon a patch of erysipelas, but they are larger than those in eczema, even attaining in some cases the size of bullæ. Erysipelas of the face, if at all extensive, is almost sure to extend up over the forehead into the scalp. Erythematous eczema in this situation does not extend beyond the hair border. Eczema rubrum is sometimes mistaken for erysipelas of the leg and is often wrongly spoken of as "*chronic erysipelas.*" The absence of the constitutional symptoms and clinical characters stated above, its chronic course and tendency to weep and form crusts are distinguishing features.

Erythema.—Erythema simplex is an acute evanescent eruption and would rarely be mistaken for eczema. There is neither scaling nor swelling of the tissues, and the itching and usual symptoms of eczema are wanting. Sometimes an erythema will persist, becoming chronic, but it maintains the same hyperæmic character, though of a passive nature, lacking all the clinical symptoms of eczema. *Erythema multiforme* itches but slightly, generally begins upon the back of the hands and forearms, the papules are larger and more succulent than those of eczema, and there is often a history of recurrence with the change of the seasons. *Erythema scarlatiniforme* simulates acute generalized eczema, but the outbreak is preceded by prodromal symptoms of general malaise, backache, slight fever, etc., which are absent in eczema. It generally begins with more or less diffuse redness and swelling, accompanied by burning and tingling and on about the fourth day commences to desquamate. This is fine and branny upon the limbs and face, but large flakes are shed from the trunk, palms, and soles. It likewise lacks the weeping catarrhal characters of eczema.

Lupus Erythematosus.—This disease often bears a very close resemblance to erythematous eczema, and mistakes in diagnosis are frequent. Lupus erythematosus, however, is more chronic in its course than eczema, and while it also appears most commonly upon the face, it occurs in variously sized, irregularly outlined, well defined infiltrated patches of a dull red color, bearing thin but quite firmly attached scales. The patches of eczema are not well-defined, the infiltration is less marked, and the scales are loosely attached. If the scales in lupus erythematosus are forcibly removed, there are numerous tiny plugs attached to them, which fit into corresponding openings of the sebaceous follicles; this is never seen in eczema. The itching is very slight in erythematous lupus, and there are no vesicles or weeping areas as seen in eczema. The eruption is also generally symmetrical in its distribution, and smaller foci are frequently seen upon the lobes of the ears and on the scalp. Finally, small white atrophic scars form sooner or later in every case—a manifestation entirely foreign to eczema.

Acne Rosacea.—This form of acne is confined to the middle zone of the face, including the nose, and adjacent part of the cheeks, the chin, and forehead, while eczema is more diffuse. The eyelids are never affected as in eczema, the color is a brighter red, and there is generally no itching. The surface temperature is cool, while that of eczema is increased and the infiltration is less than in eczema. Telangiectases are generally present, together with pustules and indurated papules which are not seen in eczema of this region. Often a seborrhoic eczema is subjoined which is generally associated with more or less dandruff in the scalp and seborrhœa oleosa about the nose and forehead. Little difficulty should be experienced in recognizing this complication. Acne rosacea is a disease of middle or advanced life, while eczema may occur at any age.

Urticaria.—Papular urticaria, a form of the disease frequently observed in children, often bears a close resemblance to papular eczema. The papules in urticaria, however, are scattered without tendency to confluence or grouping, and are comparatively short-lived. When scratched they often swell, and wheals or erythematous spots appear from time to time, which would distinguish the disease from eczema.

Lichen Planus.—Eczema is perhaps more often confounded with lichen planus than with any other disease. The papules of lichen planus, however, are distinctive in character. They are angular in outline, flat and shining, slightly scaly, often umbilicated, and of a dull red or purplish color. The eczema papule is acuminate or has a round top with circular base, and has a bright red color. Lichen planus papules develop slowly, increase in size, often becoming quite large, but they never lose their characteristic form, and when they disappear leave a well-marked pigmentation. The eczema papule develops quickly, frequently undergoes change in form and character, and disappears without pigmentation. Lichen planus papules have a peculiarity of developing along a scratch, a feature not often observed in eczema. The patches of lichen planus are more irregular in outline than those of chronic eczema, and often appear in a linear form; the characteristic papules making up the patch are generally to be seen at the periphery. Lichen planus has a predilection for the flexor surfaces of the wrists and forearms and inner side of the knees and thighs, while the patchy form is more commonly seen upon the back or sides of the neck and on the lower legs.

Pityriasis Rubra Pilaris.—This affection is almost invariably mistaken for eczema by the practitioner, for it is of rather rare occurrence and is seldom seen outside of dermatological practice. It is a very chronic disease, and extends over a period of many years. The distinguishing lesions are small, hard, yellowish or red, horny, conical papules, each of which is located at the orifice of a hair follicle. They impart to the hand passed over them the sensation produced by a nutmeg grater. These are especially prominent on the arms, forearms, thighs, and the dorsal surface of the phalanges. In the last-named location they appear as hard, black points, and when present are a certain diagnostic sign. There is nothing in eczema resembling these lesions. The disease may become generalized and then resembles squamous eczema; it may even become universal, but there are never any signs of scratching as in eczema. The skin is uniformly dull red, infiltrated, and covered with fine, horny scales. Eczema is a brighter red, the scales are larger, and somewhere there is generally evidence of scratching with oozing or crust formation. There is also a severe symmetrical hyperkeratosis of the palms and soles, and great thickening of the nails—features not generally observed in eczema.

Psoriasis.—The average case of psoriasis offers no difficulties in diagnosis from eczema. The patches are sharply defined, are covered with dry micaceous imbricated scales, are generally seen in the neighborhood of the elbow or knee, and show a preference for the extensor surfaces of the limbs. The patches of eczema are ill-defined, the crusts are darker, and are composed of dried serum mingled with epidermic scales, and they show preference for the flexor surfaces. Removal of psoriatic scales reveals numerous punctate hemorrhages, while beneath the eczema crust is a red, oozing surface. Psoriasis is always a dry eruption; eczema, even in the dry squamous form, shows catarrhal tendencies at times as a result of scratching or traumatism. The subjects of psoriasis are almost always in robust health, while eczema patients are often in ill health. The history of long duration and relapses in psoriasis is often of much service in diagnosis. Psoriasis of the scalp resembles eczema closely at times, but the eruption is drier, presents a patchy character instead of being more or less diffuse, and where it extends beyond the hair, as upon the forehead, the eruption has a sharp margin which would distinguish it from eczema. Some patches of chronic infiltrated eczema resemble those of psoriasis very closely, but they are not apt to be so sharply defined, the itching is more intense, they often become wet by scratching or rubbing, and crusts of dried blood and serum form at times. Small guttate psoriasis is sometimes mistaken for papular eczema, but scraping off the scale with the nail will usually reveal the small bleeding points; this, together with a careful examination as to the localization of the lesions and the history of the disease, will generally enable one to make the correct diagnosis.

Syphilis.—Some of the syphilodermata resemble eczema quite closely, and mistakes in diagnosis are not infrequently made. The lesions of the small papular syphiloderm generally show a tendency to grouping, often in the form of crescents or segments of a circle. Papular eczema lacks this characteristic. The color of the syphilitic papule is dull red instead of bright red as in eczema, and it is hard and shot-like to the touch, while in eczema the papule is not so firm. There is rarely itching in papular syphilis, while the itching in papular eczema is generally intense.

The pustular syphiloderm, especially that upon the scalp, is difficult sometimes to distinguish from eczema pustulosa. The syphiloderm, however, soon forms scabs, which when removed reveal a small, sharply cut ulcer, and eventually it leaves a scar. Upon removing the crusts of pustular eczema, a smooth, red, moist surface remains, and there is never any ulcer or scar formation. Squamous papular syphilis of the palms and soles is often mistaken for eczema, but it presents a circinate, sharply defined border, which by close inspection is found to be made up of separate papules which have fused together. Eczema in these regions forms a uniformly scaly patch, usually lacking the sharp definition, and the border is not made up of papular elements.

In syphilis a history of infection can often be obtained, together with evidences, at some time, of lesions upon the mucous membranes and remains of former ulcerations in the form of scars.

Granuloma Fungoides.—This disease often develops from erythematous scaly patches indistinguishable from eczema. These spots develop anywhere upon the body, sometimes in the form of erythematous plaques of round or oval form, or in distinctly eczematous scaly patches. They resist every kind of treatment and often last for years, or they may disappear spontaneously only to return again often in the same localities. Patches of eczema showing this life history should be looked upon with suspicion. When infiltration and tumefaction begin the diagnosis of mycosis fungoides is easy.

Tinea Circinata.—Ringworm is sometimes confused with eczema, especially when the lesions are numerous. The course of the two diseases, however, is very different. Tinea circinata is an acute eruption, begins usually in a small scaly spot which enlarges rather rapidly, forming a patch with a raised, red, scaly border and a more or less clear centre. The patch of squamous eczema enlarges in the same way, but there is no distinct, raised, well-defined border, only a scaly, uniform, slightly infiltrated patch, without tendency to clear in the centre. The itching in tinea circinata is slight; in eczema it is always a marked symptom. The former disease runs an acute course; the latter is a chronic form of eruption.

In *eczema marginatum*, or ringworm of the crotch and axilla, there is an eczema with a subjoined infection with the trichophyton fungus. From an ordinary eczema it can be distinguished by its raised, sharply defined, circinate or festooned border and the gradual diminution of the eruption toward the point from which the disease spread.

Whenever there remains any doubt in diagnosis, an examination of the scales by the microscope will reveal the trichophyton spores and mycelia if the eruption is one of ringworm.

Tinea Versicolor.—The clinical features of this disease are generally distinctive enough to prevent any mistakes in diagnosis. It occurs in fawn-colored or light brownish spots upon the front or back part of the upper portion of the trunk, and only rarely upon exposed parts, as the face and neck. The patches are covered with fine furfuraceous scales, but there is an entire absence of infiltration and inflammatory symptoms. The itching is slight or absent, the patient often being unaware of the presence of the eruption until attention is called to it. All of the foregoing features would distinguish this disease from eczema. Microscopic examination of the scales will always reveal the characteristic fungus which is the cause of the trouble.

Herpes.—It is necessary to differentiate herpes from vesicular eczema, although usually it is not difficult. Simple herpes, or *herpes febrilis*, either of the face or of the genitals, is an acute affection consisting of a group of vesicles which are generally larger than those of eczema. The vesicles in herpes dry up in a few days without discharging and forming a weeping patch as in eczema. Vesicular eczema appears generally in several localities, and does not consist of one or two patches in close proximity as in herpes. *Herpes zoster* generally develops in the course of a nerve or its branches, is preceded by neuralgic pains, and is made up of groups of larger vesicles or even bullæ seated on an erythematous patch; it is also unilateral. Eczema vesiculosa occurs in a disseminated manner, is not associated with neuralgia, and the vesicles are smaller and more closely set. As in herpes simplex, the vesicles in zoster dry up without discharge. Scars are often left after herpes zoster, while scarring is never seen in eczema.

Dermatitis Herpetiformis.—The mistake is very commonly made of diagnosing this disease as eczema. In the papular and vesicular varieties of dermatitis herpetiformis the eruption is very much like that of eczema. The disease, however, belongs to the herpetic group of eruptions, and by keeping in mind this fact little difficulty need be experienced.

The lesions of dermatitis herpetiformis develop in crops of grouped papules, vesicles, pustules, or bullæ, accompanied by more or less erythema. These lesions often dry into scaly, red patches, which, after remaining a short time, disappear spontaneously, only to be replaced from time to time by new crops. Eczema rarely behaves in this way, though certain forms of neurotic eczema present much the same picture. There is always rupture and discharge of the lesions, however, in eczema, while in dermatitis herpetiformis they dry up as in other herpetic eruptions without discharging. Dermatitis herpetiformis runs a very long course, lasting often for years with periods of comparative freedom, but ultimate cure in any case is not to be expected. Eczema may last a long time and become chronic, but there is never the history of repeated recurrences covering many years of one's life, as occurs in dermatitis herpetiformis. Eczema is, furthermore, a curable disease. The itching in dermatitis herpetiformis is productive of more suffering than in almost any other known dermatosis. The itching of eczema is bearable as a rule, and can be modified by treatment, whereas in this disease it is only a little or not at all relieved by therapeutic measures.

Dermatitis.—The clinical symptoms of dermatitis and eczema are about the same and are often indistinguishable. The history and course, however, are entirely different in the two affections. A dermatitis is an acute eruption, wholly of artificial origin, produced by some irritant coming in contact with the skin. It remains confined to the region irritated, and generally disappears quickly when the source of irritation is removed. Eczema excited by local means spreads beyond the area first subjected to the irritant, even though the cause is removed, and may develop in remote regions, becoming more or less chronic.

In poison-ivy dermatitis the eruption commonly appears in remote parts by auto-infection; active treatment is always needed to destroy the effects of the poison. Its acute character, however, and the history of contact with the plant, will generally distinguish it from eczema.

Eczema of constitutional origin is rarely confounded with dermatitis, for its nature is soon revealed by the history and subsequent course of the eruption.

Pemphigus.—Bullous eczema, especially as it occurs in elderly people, may resemble pemphigus vulgaris. The bullæ in pemphigus develop suddenly and without apparent cause from a perfectly normal-looking skin, no redness nor even an areola being seen. Eczema bullosa is, on the other hand, always associated with inflammatory symptoms and the bullæ rupture and produce a weeping patch. When the bullæ in pemphigus break, a painful non-exuding bright red area remains. Pemphigus is generally preceded by constitutional disturbances and is a grave disease, the patients dying in either the first or the second attack.

"*Pemphigus foliaceus,*" a more generalized form of the disease, spreads rapidly over the body surface, with the production of large flaccid bullæ, which dry into large thin flakes or are rubbed off, leaving raw areas of variable extent without infiltration. Flaccid blebs are never seen in eczema, there is always infiltration, and the disease rarely becomes universal as in pemphigus foliaceus. Moreover, the latter disease goes on to a fatal termination, while eczema never imperils life. Itching is generally absent or slight in both forms of pemphigus, which would distinguish them from eczema.

Pityriasis Rubra.—This is another rare and fatal disease, which in its early stages bears a resemblance to eczema. It begins with redness and scaling, as in squamous eczema, but soon becomes generalized and universal. Large, thin epidermic flakes are continually exfoliated, leaving a bright red moist surface, but there is no infiltration nor weeping as in eczema. Eczema rubrum and eczema squamosum, on the contrary, have a more localized distribution and exhibit the exudation, infiltration, and crusts which are characteristic of the eczematous process. There is likewise no itching in pityriasis rubra, which would distinguish it from eczema. The disease, when once begun, continues without abatement until it eventually destroys the life of the patient.

Impetigo Contagiosa.—This is an acute affection of short duration, occurring most commonly upon the face and hands, though in some cases it may extend over the body. The lesions begin as vesicles or small blebs, which speedily become pustules; these rupture and dry into dark crusts. The whole process is superficial, the lesions springing from an uninfiltrated base; and the latter, besides, are generally few in number and scattered. In pustular eczema the lesions are smaller and more numerous, are not so isolated, and develop from an infiltrated base, drying into thin scales, from beneath which pus can be expressed.

In impetigo contagiosa there is often a history of the same eruption in other members of the family, or evidence, if in an adult male, of direct infection from a barber shop.

Pediculosis.—Pediculosis corporis is often mistaken for eczema. The lesions seen in this affection, however, occur particularly about the back and chest, around the neck and shoulders, and about the waist and over the buttocks. Eczema is never limited to these regions. In pediculosis the intensity of the itching and the great number of scratch marks are out of all proportion to the lesions present. There are never any patches as in eczema, but only scratch marks and torn papules capped with a blood crust.

Care in examination of the clothing and even of the skin itself will often reveal the parasites or their nits.

"*Pediculi capitis*" are a frequent cause of pustular eczema of the scalp, especially in children. In every pustular eczema, whether in children or in adults, this factor must be first eliminated. Either the parasites themselves or their nits can always be detected, and in children enlargement of the posterior cervical glands is almost a sure sign of pediculosis.

"*Pediculi pubis*" may cause an eczema about the genitals, in the axillæ, or on the edge of the eyelids. With a hand-glass the crab-louse can generally be detected firmly attached to the skin at the base of a hair, or its nits are found on the shaft of the hair.

Scabies.—It is very important to differentiate scabies from eczema, since the treatment for one is inappropriate to the other. The lesions of the two diseases resemble each other in a marked degree, and in some cases a distinction cannot be made; in fact, eczema is sometimes caused by the acarus scabiei. In the early stages of scabies, careful search will usually reveal the furrows produced by the burrowing of the female acarus, but in older cases these are masked by the irritation and changes in the skin produced by scratching. The distribution of the eruption in scabies is the chief feature upon which the diagnostician must rely. The regions commonly affected are the interdigital spaces and adjacent surfaces of the fingers, the flexors of the wrists, the elbows, axillæ, buttocks, and thighs. In females the mammæ and nipples are favorite sites, and in males the glans and body of the penis. In children pustular lesions upon the hands, feet, and buttocks are almost sure to denote scabies. The face and scalp are never invaded by this disease. Eczema may also occur in all these localities, but the lesions are not so scattered, often form patches, which are not seen in scabies except in very aggravated and long-standing cases, and extend to the face, scalp, and other regions not affected in scabies. There is, finally, often a history of infection from fellow-workmen, room-mate, or other members of the family.

Sycosis.—For the diagnosis between eczema and sycosis the reader is referred to eczema of the beard.

Tinea Favosa.—See eczema of the scalp.

Seborrhœa.—See eczema seborrhoicum.

PROGNOSIS.—The question as to the curability of eczema can undoubtedly be answered in the affirmative. It is quite another thing to be able to say when a given attack will be cured or whether the patient is liable to suffer a relapse.

To answer these questions correctly it is necessary for the physician to be familiar with the disease in its varied and manifold phases. He must know his patient as well as the various possibilities and vagaries of the disease itself. Eczema at the best is a very rebellious affection, and one must be guarded against giving a prognosis without carefully weighing the case in all its bearings. Experience, then, must be the physician's chief reliance, as little more than hints or generalizations can be acquired from others.

If the cause of the disease in any given case is known and removable, the chances of a quick recovery are generally good. If the cause has been long in operation, however, it must not be forgotten that the eruption may continue and prove rebellious after this is removed.

Eczema in children and infants, being due generally to known and removable causes, is less rebellious than some other forms and a favorable prognosis can be given. The great tendency to exacerbations in the case of infants, dependent upon irritation of the gastro-intestinal tract through teething and other causes, should, however, be borne in mind.

In acute vesicular types of eczema, a speedy and permanent recovery can usually be expected. The forms of eczema requiring more guarded prognoses are the chronic papular, the neurotic and gouty forms, those in elderly people, and certain obstinate types dependent upon locality. Chronic eczema of the scalp is extremely rebellious, as is also chronic squamous eczema of the palms. Eczema of the anus and scrotum, and the form of the eruption which is seen on the lower legs, and which is dependent upon varicose veins are extremely difficult to cure. Relapses are generally to be expected in gouty, neurotic, and debilitated subjects. In regard to contagion and the likelihood of transmitting the disease by heredity, a negative answer can assuredly be given.

TREATMENT.—From what has been said thus far, it may readily be inferred that the subject of the treatment of eczema is of vital importance. There is no subject in dermatology of so much consequence to the practitioner, for eczema constitutes a large majority of all the cases of skin disease that come under his care. Unfortunately, however, it is one of the most difficult diseases to treat and often proves most obstinate and rebellious even in the hands of the expert.

In any given case it is necessary at first to discover if possible the cause, and if this is a local one and can be eliminated the simplest local measures will often suffice. But, as already seen, the disease is rarely due to local causes alone, and in order to subserve the best interests of the patient as regards relapses and future attacks, it is necessary to take into consideration every possible factor that may have a bearing upon the case. Every deviation from health should be carefully looked into and all irritating and depressing influences removed as far as possible. Family tendencies, individual idiosyncrasies, temperament, habit, environment, etc., must all be duly weighed if the best results are to be attained. It is the physician with the best knowledge of disease in general who will meet with the greatest success in the treatment and management of eczema. There is no specific for the disease, and every case must be treated on its individual merits. Eczema is curable in almost every instance, and the removal of the eruption is never prejudicial to the patient, but on the contrary is always of great benefit to him. The old theory of *scattering the poison* to internal organs or of *driving it in* is no longer tenable in the light of modern pathology and general medical research.

The remedies and measures employed in the treatment of eczema relate to those having a constitutional effect and those used locally.

Constitutional Treatment.—This comprises dietary, hygienic, and medicinal measures, which if judiciously employed will always be found of great service. It will be necessary only to indicate in a brief way the dietary and other measures that have, by experience, proved the most useful in this disease, leaving much to the good judgment of the physician.

Diet and Hygiene.—There is no fixed diet that will apply to all cases of eczema, as it will necessarily vary according to the requirements of each individual case. If it were possible to generalize at all, I think a non-nitrogenous, easily assimilated diet would be suited to the greatest number of cases. In infants and children the regulation of the diet is perhaps the most important part of the treatment, for in these subjects it is most often grievously at fault. The nursling should be limited to milk or, if the breast milk is insufficient, to cow's milk properly modified, and not allowed to have a taste of everything on the parents' table, including tea, coffee, beer, and all kinds of solid food. This practice is unfortunately very common among children of the poor, and it is needless to say that eczema flourishes under such conditions. Older children and those in the better walks of life are often allowed confectionery, rich cakes, pastry, soda water, and all kinds of indigestible things. All these should be strictly prohibited if good results in the management of the eczema are to be expected. There is one article of food which, I think, is responsible for more trouble in the eczema of infants and children than any other one thing; I refer to bananas. Bananas are nutritious, easily accessible, and convenient, for which reasons they are consumed in large quantities. However well they may be digested and assimilated by some healthy subjects, I feel certain they are extremely harmful in those suffering from eczema. This applies to adults as well as to children—a fact which I have been able to demonstrate to patients time and again. In acute eczema it is generally advisable to restrict the diet to one of milk, bread and butter, eggs, chicken, fish, and vegetables, with possibly meat, such as beef, lamb, and mutton two or three times a week. All salt and highly seasoned meats, as pork, corned beef, ham, and sausages, together with richly fried and made dishes, rich gravies, condiments, pastry, cheese, pickles, nuts, olives, etc., should be forbidden. Such a restricted diet is likewise appropriate to the gouty subject, who should avoid, in addition, excess of starches and sweets. These patients should also use freely some good diuretic water, such as Poland, Bethesda, or Lithia water, taking it preferably before eating. In the plethoric a diet of milk and vegetables, or at least a non-albuminous regimen devoid of stimulating or heating articles, is very essential.

When there is an impairment of the digestive functions, as evidenced by dyspepsia in one form or another, a diet must be selected appropriate to the condition present. Eczema patients often suffer from fermentation and acidity, and complain much of flushing after eating. The avoidance of sweets, starches, pancakes, fritters, crullers, and the numerous class of articles that are difficult of digestion is to be advised in these cases. Strawberries, shell fish, and any article of diet that is known to cause eruptions of any kind should be avoided by those suffering from eczema.

In old people and in those debilitated from any cause, a nutritious supporting dietary is necessary. This is particularly true in those reduced from nervous strain, anxiety, or overwork, and in patients of a strumous or lymphatic habit. A diet of milk, rich cream, eggs, butter, and easily assimilated foods, as chicken, fish, fresh vegetables, graham bread, and wheat cereals, is most desirable in these cases. Milk, slightly warmed, given without any other food an hour before eating and continued for indefinite periods, is most efficacious in neurotic and debilitated subjects. In all varieties of eczema alcohol in every form should be avoided, including even the lighter wines, champagne, beer, ale, and porter. In elderly debilitated patients and in those accustomed to its use, a small allowance may sometimes be advantageously given. Tobacco in any form aggravates eczema, especially eczema of the anus, and in those having weak digestions it should never be used. Tea, coffee, and chocolate should be taken only sparingly by eczema patients.

Fresh air, both in the dwelling and out of doors, together with a moderate amount of exercise, as walking, rowing, golfing, bicycling, or gymnastic exercises, is all-important in connection with the treatment of many cases of eczema.

The clothing worn by these patients is a very important consideration. Woollen should never be worn next to the skin, underwear of muslin, silk, or linen mesh being best suited to this condition. For warmth, woollen may be worn over these if necessary, but this matter is better regulated by changes in the outer garments. The heavy bundling up that infants are often subjected to is to be deprecated. This applies particularly to the babies of the poor, who are often wrapped in yards of heavy coarse flannel, which is not only a great hardship to the child, but is productive of much harm.

The subject of bathing deserves special mention, for upon proper judgment in this respect much may depend. Indiscriminate bathing is undoubtedly harmful, and Turkish and Russian vapor baths as a rule should be discouraged. The daily bathing of the sound skin, followed by mild friction, is, however, desirable and indeed necessary in many cases; but if a large part of the body surface is affected the daily bath must be omitted. In these cases alkaline baths two or three times a week are very serviceable. One of the most useful formulæ for a bath powder is the following: ℞ Potass. carbonat., ℥ iv.; sod. carbonat., ℥ iij.; sod. biborat., ℥ ij. M. This should be used in a thirty-gallon bath, together with a pound or two of starch. Sulphuret of potassium may be used in the strength of from ℥ ij. to ℥ iv. to thirty gallons in similar cases. Glycerin, from ℥ iij. to ℥ vi. to thirty gallons, is also a useful form of medication. The first inclination in most patients is to wash the part affected with eczema, not alone for the purpose of keeping it clean, but because much relief is temporarily experienced thereby. This practice, however, interferes most seriously with repair, and must be strenuously prohibited in all cases. The value of treatment at various mineral springs, where patients bathe and drink of the waters, is in my opinion questionable. A certain few may receive benefit, but I believe that the importance sometimes attributed to them in the treatment of eczema is greatly exaggerated.

Drugs.—The indications for the administration of medicines in eczema are generally to be looked for in the patients themselves and not in the disease. While it is very essential to appreciate the effects of remedies in the various stages of the eruption in order to select those most suited to the condition, it is nevertheless too true that undue attention is often given to the skin itself and too little regard paid to the individual.

The truth of this statement is nowhere more apparent than is seen in connection with the single symptom of pruritus. From the very beginning of an attack of eczema the first and chief concern of the patient is to get relief from this distressing symptom. The physician, in his efforts to accomplish this, is often led to resort to sedatives of one form or another, such as opium, chloral, bromides, phenacetin, sulphonal, trional, etc. The ultimate result is an aggravation of the eczema, and hence an increase in the itching, the very symptom for the relief of which they were given. It may safely be put down as an axiom that *eczema will cease to itch when it is cured, and not until then.* It is therefore both useless and harmful to use antipruritic drugs, but instead every effort should be made to cure the disease as quickly as possible.

As already mentioned, disorders of the gastro-intestinal tract are most commonly met with in connection with eczema, and these should receive the physician's first attention.

Constipation may be relieved by small and continuous doses of fluid extract of cascara sagrada or by the well-known pill of aloin, belladonna, and strychnine, given at bedtime. I have found a pill containing gr. i. aloin, gr. i. extract cascara, and gr. $\frac{1}{4}$ extract nux vomica of very great service in this connection. Calomel in small doses, gr. $\frac{1}{10}$ to gr. $\frac{1}{6}$ three or four times a day for several days in succession, with a mild saline before breakfast, such as a teaspoonful or two of equal parts of sulphate and phosphate of soda in half a glass of water, will often prove effective. The pill of aloes and iron of the Pharmacopœia is likewise an excellent remedy, given about three times a day. Saline aperients, as Rochelle, Glauber's, or Carlsbad salts, and the laxative mineral waters Hunyadi János, Rubinat, etc., are useful in some cases. Care must be taken, however, not to use these too continuously, except in plethoric subjects and in those with much liver torpor. In many cases it is advisable to begin by a rather smart purge, as a five-grain blue pill for a few nights, followed by a seidlitz powder or citrate of magnesia the next morning. A pill of blue mass, colocynth, and ipecac, containing gr. iiss. each of blue mass and compound extract of colocynth and gr. ss. of powdered ipecac, given two at bedtime, and repeated the second night following, is particularly serviceable. I have also gotten most excellent results from the following: ℞ Leptandrin, gr. viij.; podophyllin, gr. ij.; ipecac, gr. v.; ext. hyoscyami, ʒ ss.; ext. belladonn., gr. ij.; ext. aloes purg., ʒ ss. M. ft. in pil. No. xxx. Sig. Two every second night for three times. It is generally advantageous to repeat these bilious pills at intervals of two or three weeks. For more or less continuous use a pill containing gr. i. calomel and gr. $\frac{1}{8}$ to gr. $\frac{1}{6}$ podophyllin has proved very useful in my hands; this pill may be given once or twice a day, preferably at night.

For the treatment of constipation and stomach derangements in infants, the reader is referred to Infantile Eczema.

In dyspeptic conditions, besides the dietary regulations already referred to, the following therapeutic agencies will be found of service. In the flatulent and atonic forms, alkalies and bitters are required, as also the dilute mineral acids. I have found that gtt. x. to xv. of dilute nitromuriatic acid, given well diluted before eating, relieves the flatulency and consequent flushing so often complained of. Strychnine or nux vomica is likewise effective in this condition. Bismuth, liquor potassæ, magnesia, and bicarbonate of soda are useful in cases of acidity, and much good is often derived in similar cases from a mixture of rhubarb and soda. A good formula is: ℞ Pulv. rhei, ʒ ss.; sod. bicarb., ʒ ij.; pulv. ipec., gr. x.; aq. menth. pip., ad ℥ iij. M. Sig. Teaspoonful well diluted before eating.

Gouty subjects require alkalies, as citrate and acetate of potassium in doses of from ten to twenty grains three times a day. These may be given separately or combined, and generally a little iron taken with them increases their effectiveness.

The alkaline diuretics, benzoate of soda or lithia, and the free use of Poland, Lithia, or natural Vichy waters, can be prescribed with benefit to these patients. Salicin and colchicum may be given in some of the more chronic cases, but their efficacy in most instances is somewhat doubtful. It is never advisable to continue these remedies for long periods of time, but they should be occasionally interrupted and general tonics of iron, quinine, cinchona, etc., substituted.

In the strumous and debilitated, supporting tonic treatment is needed, such as cod-liver oil, quinine, hypophosphites, syrup of iodide of iron, the glycerophosphates, etc.

In all cases of acute eczema salines and gentle aperient mixtures are indicated at first, to be followed later by more tonic remedies. One of the most useful mixtures in the acute stage of the disease is that known as Startin's mixture, which is made as follows: ℞ Magnes. sulphat., ʒ iv.; ferri sulphat. exsiccat., ʒ i.; acidi sulphur. dil., ʒ iij.; syrup zingiberis, ʒ vi.; aquæ, ad ℥ iij. M. Sig. Teaspoonful in water after meals through a tube. In cases in which there is anæmia, chlorosis, malaria, or other general disease, the usual treatment employed in those conditions should be instituted. The preparations of iron best suited to the treatment of eczema are reduced and dialyzed iron, the citrate of iron and ammonia, and the citrate of iron and quinine.

Warburg's tincture, with or without aloes, is often a very valuable remedy, and ergot in selected cases may be given with benefit.

Arsenic is useful in a very limited number of cases, and should only exceptionally be resorted to. Its indiscriminate employment cannot be too severely condemned, for it is a dangerous remedy and is often productive of much harm. It is probably used less by those especially conversant with cutaneous medicine than any one remedy or class of remedies. It should never be given in acute cases, nor to patients in whom the digestion is weak or imperfect. In chronic and inveterate cases of the squamous and infiltrated types it is sometimes serviceable, but even in these it is better not to resort to it until all other remedies have proved ineffectual. It is chiefly of value in those cases of neurotic eczema in adults, in whom the eruption develops in crops from time to time, and is most rebellious to treatment of any kind. It is also practically the only remedy that will control the bullous form of the disease which occurs in elderly people. The preparations generally employed are arsenious acid, Fowler's solution, liquor sodii arsenitis, and arsenious acid combined with black pepper in the so-called "*Asiatic pill.*" I think the best results are obtained with the soda salt, for although it is weaker than the potassium salt it is better borne by the stomach and can be continued for a longer period. It is best given in small, frequently repeated doses, beginning with one or two minims, increased slowly to six or more minims every two hours. Fowler's solution may be given in the same manner, but in smaller doses. The usual dose of arsenious acid is from gr. $\frac{1}{50}$ to gr. $\frac{1}{20}$ three or four times a day. From three to six of the Asiatic pills, each containing gr. $\frac{1}{30}$ arsenious acid and gr. ij. to iv. of pepper, may be given during the twenty-four hours. In the administration of arsenic it is necessary to push it to the point of tolerance to produce the desired effect. It is always advisable to examine the urine at frequent intervals during the administration of this remedy, and upon the first evidence of abnormal kidney action it should be discontinued.

Local Treatment.—Success in the treatment of eczema will depend largely upon the proper selection and application of the various remedies and measures employed locally. There is no case that does not require local treatment in one form or another. If an opposite effect than the one expected is produced by any given application or procedure, no one will be more quickly aware of this fact than the patient himself. It is essential, therefore, to the interests of the patient, and often for the sake of his own reputation, that the physician should have this part of the subject well in hand. It is not necessary nor even advantageous to know all the newer remedies and complex formulæ that are continually being advocated. What is needed is a knowledge of the general principles governing the use of the more common remedies and a familiarity with the drugs themselves and the effect they have upon diseased skin. In the treatment of skin diseases, as in every other branch of medicine, the simplest procedures are often the most successful, but the important question is when to apply them and how to apply them. A remedy may be used by one physician with the very best effect, while the same in the hands of another, used in precisely the same condition, will prove most disastrous. This is generally dependent upon the form in which the remedy is used, whether as a lotion, ointment, paint, etc., or upon the manner in which it is applied.

Selection of Remedies and Methods of Treatment.—In choosing the remedies the physician should be governed by the character and intensity of the inflammation, the locality and extent of surface affected, and the secondary changes that have taken place. It is also often necessary to consider the occupation, habits, and social position of the individual, in order to suit the treatment as much as possible to his convenience.

It is always a good rule to employ the very mildest treatment possible when the patient first comes under observation, the remedies being strengthened from time to time. The mistake is often made of employing too strong remedies at first, which not only proves disastrous, but destroys the confidence of the patient at the beginning. In a general way it may be said that lotions—particularly those carrying powders in suspension—agree with most skins better than ointments. Upon discharging surfaces they are as a rule much more satisfactory than dusting powders, for the latter cake and subsequently irritate. If the surface affected is very large, it is obvious that to use a lotion over the whole would not be feasible, and it is then necessary to soak strips of linen or gauze in liniments which can be laid on or wrapped about the part. Ordinarily lotions are sopped on by means of a piece of old linen or gauze; it is seldom necessary to rub them in.

In using ointments much depends upon the method of application. In acute cases in which a soothing effect is desired, it is essential that the ointment be spread upon surgical lint and bound on in the manner of a plaster. It is useless in such cases to rub it on with the fingers. In chronic cases requiring stimulation, strong salves may be advantageously rubbed in and then bound on.

In certain rare instances neither lotions nor salves will be well borne and other forms of application, such as powders, pastes, plasters, gelatins, soaps, paints, etc., must be employed.

Other methods which may be classed as mechanical, such as counter-irritation, circumcision, use of rubber bandage, scarifying, hot water, alkaline baths, etc., are referred to in their proper places.

Measures to be Employed in Acute and Subacute Eczema.—The first thing to do is to remove crusts if present. This is best accomplished by laying on strips of linen soaked in olive or almond oil; by soaking with a three to five per cent. salicylic oil; or by the use of alkaline emulsions of bicarbonate of soda, borax, etc. When the surface is cleansed, the proper remedy should then be applied, great care being observed not to employ it too strong.

For freely discharging surfaces *dusting powders*, generously employed, are of greatest service. Those most commonly used are plain corn starch, rice powder, chalk, talc, kaolin, lycopodium, and magnesium carbonate. The stearate of zinc with salicylic acid or salol and the oleates of zinc or bismuth have the advantage of caking less with the secretions than do some of the other powders.

It is often advantageous to add to the simple powders equal parts of oxide of zinc or one part of bismuth subnitrate, boric acid, or camphor to four of the powder. In the same manner salicylic acid, salol, or acetanilid in strength of from twenty to thirty grains to the ounce may be useful additions in some cases. After the excessive weeping has been arrested by the use of dusting powders, it will be found most convenient to use some drying, slightly astringent lotion. *Lotions* are very cooling and grateful to the patient, and are to be preferred in most cases of acute vesicular or erythematous eczema. One of the most useful in acute vesicular eczema is composed of a drachm each of carbonate of magnesia and oxide of zinc in four ounces of water. Boric acid in three or four per cent. strength may be added to this lotion when needed, and if the itching is excessive, one per cent. of carbolic acid may likewise be added. Duhring and White employ in the acute oozing stage lotio nigra, either in full strength or diluted one-half with lime water, and they report very favorable results from its use. The eruption is bathed with it for fifteen or twenty minutes, the sediment is then allowed to dry on and a plaster of oxide of zinc ointment is immediately bound on. The applications of the lotion are made every ten or twelve hours. In acute erythematous eczema there is no application so useful as the following lotion of calamine and zinc: ℞ Acid. carbol., ʒ ss.; pulv. calamini prep., ʒ i.; zinci oxidi, ʒ ij.; glycerini, ʒ iij.; aq. calcis, ʒ iv.; aq. rosæ, ad ℥ iv. This should be dabbed on two or three times a day and the sediment allowed to remain on. It is a most cooling and soothing application. In some cases I have found it advantageous to substitute lotio nigra for the lime-water in this lotion. It must be remembered that some skins do not tolerate either glycerin or carbolic acid; in such cases almond oil may be substituted for the former and dilute hydrocyanic acid for the latter.

Another useful lotion in papular vesicular eczema contains boric acid two and one-half per cent., zinc oxide and bismuth oxychloride each four per cent. in cherry-laurel water.

In acute papular eczema of the dry, itchy type, a cooling lotion recommended by Cæsar Boeck, of Christiania, is particularly serviceable. This consists of powdered starch and talc each 100 parts, glycerin 40 parts, lead water 200 parts. It should be used first diluted with two parts of water. In this same type of eruption the magnesia and zinc lotion just referred to, with the addition of three to six per cent. of ichthyol, will be found very useful.

When there is an extensive oozing surface *liniments* prove more serviceable than either powders or lotions. The parts should be enveloped in cloths soaked with the liniment, and these should be changed about twice a day. In this way excessive drying and subsequent irritation and injury are prevented. Linseed, almond, or olive oil may be used combined with glycerin, lime-water, dilute alcohol, etc. Equal parts of linseed oil and lime-water (carron oil) will be found very useful in this connection.

Ointments may often be employed with great benefit in acute stages of the disease. Great care is necessary, however, not only in the selection of the ingredients, but also as regards the manner in which they are incorporated. Much harm may be done by the use of a salve made with a rancid ointment base or one made with a base naturally irritating to an inflamed skin. Vaseline or cosmoline, except in special instances, should not be used as a base for ointments employed in acute stages of the disease. Benzoated lard has the disadvantage of becoming easily rancid, and lanolin has too much body, but if mixed in the proportion of about one to four with some soft emollient, the latter makes a good ointment base. Freshly made cold cream or rose-water ointment makes the best base for salves; it is soothing and the evaporation of the rose water it contains produces a cooling effect. Duhring gives a good formula for making cold cream, which consists of rose water and oil of sweet almond, 10 parts each; white wax and spermaceti, 2 parts each; these to be emulsified with sodium biborate, one-half of one per cent.

Much likewise depends upon the way an ointment is made. If it is not perfectly smooth, but contains gritty particles, it is sure to irritate, no matter how fresh or mild the ingredients may be. Some substances, such as tannic acid, resorcin, etc., occur in the form of tiny sharp crystals, and unless these are previously dissolved before being incorporated in the salve, harm will surely follow.

For a simple protective nothing is better than oxide of zinc ointment in the strength of a half drachm to the ounce of cold cream. Bismuth subnitrate or oleate of zinc may be used for the same purpose and in the same strength. A very soothing ointment for use in acute eczema is one composed of prepared calamine powder, gr. xx.; zinc. oxid., gr. xxx.; acidi carbolici, gr. v.; ungt. aquæ rosæ, ℥ i. Instead of the carbolic acid a half drachm of tincture of camphor may prove of more benefit in some cases. Salicylic acid in mild strength is a most useful remedy in acute and subacute eczema. Used in the strength of two per cent. in the zinc ointment already referred to, it rarely fails to do good. In the form of a paste, first recommended by Lassar, it is an extremely efficacious remedy. The formula is as follows: ℞ Pulv. acidi salicylici, gr. v.; zinci oxidi, pulv. amyli, āā ʒ ij.; vaselini, ℥ ss. In acute eczema, especially of the face and scalp and in eczema of the toes, a tannin ointment composed as follows is very effective: ℞ Acid. carbol., gr. v.; pulv. acidi tannici, tannin. glycerit., āā ʒ ss.; ungt. aq. rosæ, ℥ i. A useful ointment in acute erythematous eczema is one composed of four per cent. boric acid and two per cent. salicylic acid in equal parts of lanolin and rose-water ointment.

Hebra's diachylon ointment, used alone or with the addition of one per cent. of salicylic acid, or mixed with equal parts of zinc ointment, is very valuable in acute and subacute eczema. Its ingredients are: ℞ Olei olivæ opt., ℥ xv.; lithargyri, ℥ iij + ʒ vi.; aquæ q. s., to which are added ʒ iij. olei lavandulæ. The oil is mixed with a pint of water, heated to boiling; then the finely powdered litharge is stirred in until it cools.

In certain cases *pastes* composed of tragacanth, gelatin, etc., are tolerated better than salves. Unna's gelatin paste or "*Zinc-Leim*" is composed of gelatin. alba, ʒ vi.; glycerini, ʒ ix.; aquæ, ℥ ij.; zinc. oxid., ʒ vi. The gelatin is melted in the water with heat, then the glycerin and zinc are added. A hard jelly results upon cooling, which requires liquefying in a water-bath before it is applied. This is then painted on with a brush, and while it is drying, fibres of absorbent cotton are made to adhere to the surface. It may be washed off or stripped off *en masse*, and is a cleanly and effective dressing.

Gelanthum, one of the newest ointment bases, consists of gelatin and tragacanth each two and one-half per cent. and glycerin five per cent. in water. Any medicament can be incorporated with it. It is simply necessary to paint it on with the finger when it quickly dries, leaving a coating upon the skin; it can be readily removed with a little water.

The *salve muslins* devised by Unna are very useful methods of making applications to the skin, but as they are imported it is not always possible to get them fresh. On this account they are not to be recommended for general use.

Measures to be Employed in Chronic Eczema.—In the local treatment of chronic eczema various remedies and methods are employed, among the most useful of which are the different preparations of mercury and tar. These may be used in the form of either lotions or salves and may often be combined with advantage. The mercurials of especial value are ammoniated mercury and calomel used in strengths varying from two to ten per cent.; the yellow oxide and red oxide in two or three per cent. strength; the nitrate and oleate in two to five per cent. strength; and in certain cases the bichloride and red sulphide. Sometimes the mercurials are advantageously combined with sulphur. A most useful formula for chronic indolent patches consists of ℞ Ungt. hyd. oxidi rubri, ʒ iss.; ungt. sulphuris, ʒ iij.; ungt. zinc. oxid., ad ℥ i. M. In chronic impetiginous eczema the following white precipitate ointment is particularly effective: ℞ Acidi carbol., gr. v.; bismuth subnitrat., ʒ ss.; ungt. hydrarg. ammoniat., ʒ ij.; ungt. aq. rosæ, ℥ i. M. In a similar condition, especially when located upon the scalp, the following combination will be found useful: ℞ Hyd. ammoniat., gr. xxv.; calomel, gr. xx.; acid. salicylici, gr. xv.; ungt. hydrarg. nitrat., ʒ iij.; ungt. aq. rosæ, ad ℥ i. M. Among the tars most commonly employed may be mentioned: Pix liquida, oleum cadinum, oleum rusci (crude), ichthyol and thiol. A very effective tar ointment is that known as Ungt. picis et zinci and is made as follows: ℞ Ungt. picis liquid., ʒ ij.; zinci oxidi, ʒ ss.; ungt. aq. ros., ad ℥ i. M. This may be used alone or combined with equal parts of Hebra's diachylon ointment. It is a most effective antipruritic and is very serviceable in chronic infiltrated patches and in eczema of the anus and scrotum. Oil of cade and oleum rusci may be used pure, in which case they are painted on to chronic scaly patches, or they may be used in solution in alcohol in strength of two parts of the tar to one of alcohol. In ointments they are generally employed in strength of ʒ ss. to ʒ i. to the ounce. Ichthyol and thiol may be used in the same manner. The latter has less odor than ichthyol, but in my experience it is less effective. They may be used in watery solution, five to ten per cent. or stronger, or they may be employed in ointment in strengths varying from three to fifty per cent.

In the treatment of infiltrated localized chronic patches, a solution known as "*liquor picis alkalinus*" is most valuable. Its formula is, ℞ Picis liquidæ, ℥ ij.; potass. causticæ, ℥ i.; aquæ, ℥ v. M. Dissolve the potassa in the water and add the tar with rubbing in a mortar. It is generally used diluted five to ten times with water, and after rubbing the patches once or twice a day with it a soothing ointment is applied. It may also be employed as an antipruritic lotion in less chronic conditions in strength of from one to three drachms to the pint of water or in an ointment in strength of ten to twenty minims to the ounce. For chronic localized patches the following ointment will also be found of great service: ℞ Picis liquid., ʒ ij.; plumbi glycerol., ʒ iij.; ungt. diachyli (Hebra), lanolin., āā ℥ ss. M.

In addition to the remedies already mentioned some other drugs, such as resorcin, chrysarobin, pyrogallic and salicylic acids, rhubarb, beta-naphthol, iatrol, permanganate of potassium, etc., may serve a useful purpose in the treatment of chronic eczema. Resorcin may be used in a lotion or ointment in strength of from two to six per cent. Chrysarobin, pyrogallic and salicylic acids are often conveniently dissolved in liquid gutta-percha or collodion and used as a paint which may be applied once or twice a day. They may be used in strength of from three to ten per cent. Powdered rhubarb in four or five per cent. strength in an ointment is useful in chronic parasitic types of the disease. A four-per-cent. ointment of rhubarb combined with equal parts of ungt. picis et zinci, is likewise of great service. Beta-naphthol and iatrol are generally used in about three-per-cent. strength, while permanganate of potassium in one or two per cent. watery solution is useful as a paint.

The following combinations will be found of service in chronic squamous types of the disease: ℞ Magnes. carbonat., zinci oxidi, āā ʒ i.; sod. salicylat., ʒ iss.; iatrol, gr. l.; aquæ, ad ℥ iv. M.; and ℞ Acid. salicylici, gr. xv.; Acid. pyrogallici, gr. xxv.; Spts. vini rectificat., ℥ i. M.; also ℞ Ichthyol, gtt. xx.; resorcini, gr. x.; Aquæ, ℥ i. M.

It only remains to refer to the use of medicated soaps, soap plasters, caustics, and counter-irritants in the treatment of chronic eczema. Almost every remedy employed in the treatment of eczema has been incorporated into a soap, so that we have ichthyol, salicylic, naphthol, bichloride, tar, and innumerable other kinds of medicated soaps. Personally I have had but little experience in the use of these, but if properly employed, allowing the lather to dry upon the diseased skin, they should be useful in the treatment of eczema.

Various forms of soap plasters have been recently recommended, many of which are certainly serviceable. One of the best is Duhring's modification of Pick's salicylic soap plaster. It is especially indicated in subacute or chronic vesicular or vesico-papular patches, and is composed as follows: ℞ Emplast. saponis (U. S. P.) liquefact., 90.0; ol. olivæ opt., 10.0; acidi salicylici, 2.0. M. It should be spread on muslin or thin kid and applied continuously.

Hebra's soap treatment for chronic indolent patches is extremely effective. It consists in rubbing into the patch a piece of sapo mollis the size of a walnut by means of a piece of white flannel dipped into water. The affected part is thoroughly scrubbed with the lather until all the scales are removed, leaving a bright red, tense, oozing surface. Plasters of oleate of zinc or diachylon ointment are then firmly bandaged on and left until the next application of the soap. This is usually done about twice a day and results in a rapid removal of the diseased patch. Tincture of green soap, two parts green soap to one of alcohol, may be used for the same purpose, or a mixture of equal parts of green soap, oil of cade, and alcohol. The caustics most commonly employed in the same capacity are liquor potassæ and solutions of caustic potash, five to ten grains to the ounce. Crocker has found that in certain cases of inveterate eczema in which relapses are frequent, counter-irritation to the spine sometimes proves curative. For the upper half of the body he applies it to the nape of the neck, and, for the lower half, over the lumbar enlargement. Dry heat or a mustard leaf may be applied in this way without fear of exciting an eczema in the neighborhood.

Regional and Special Varieties of Eczema.

Infantile Eczema.—This is generally understood to include all cases of eczema occurring in children under five years of age, and, according to statistics made by Crocker in London, about one-third of all these begin during the first year of life.

Eczema in babies and young children generally begins somewhere upon the head, usually in the centre of the cheeks or behind the ears. First there is a scaly patch which enlarges slowly and soon develops vesicles and pustules which rupture and dry into more or less thick, blood-stained crusts. As the cases ordinarily come for treatment, they present large crusted patches of eruption on both cheeks, on the forehead, chin, ears, neck and scalp, and often similar patches of disease upon the extensors of the forearms and wrists. The skin is always affected in a symmetrical manner and in the worst cases the whole head may be uniformly involved, saving a small area around the mouth, nose and eyes, where the white, healthy skin stands out in striking contrast. The eruption often extends to other parts of the body and limbs, and in older children may become more or less general.

The disease is frequently complicated by furuncles and abscesses situated especially upon the scalp, face, and neck, and in poorly nourished and strumous infants, conjunctivitis, blepharitis, or otorrhœa may likewise coexist. In children of the poor, pediculi play an important part in producing and keeping up the trouble.

The posterior cervical lymphatic glands are considerably enlarged in these cases and are a source of great concern to the parents. These rarely break down, however, but disappear slowly when the eruption gets well.

Though eczema may occur in ill-nourished, strumous, and rickety infants, it seems to have been my experience to find it more commonly in well-nourished, fat, and healthy subjects. In a few cases the disease is apparently inherited, in which event it is liable to continue after infancy and often become chronic in adult life.

The delicate skin of the infant is very susceptible to local irritants of one form or another, and no doubt the eczema is due to local causes alone in some cases. The great majority, however, are dependent upon improper or excessive feeding and disorders of the gastro-intestinal tract engendered thereby. Dentition is often spoken of as a cause of the trouble, but in most instances the eruption develops long before the teeth are thought of. The disease is always aggravated by teething, but in a reflex manner through the disturbances of digestion which it causes.

In a certain few cases, infantile eczema, in both the male and the female, occurs reflexly from an adherent prepuce and is not cured until this is relieved by circumcision or by stripping.

It is important to differentiate ordinary infantile eczema from syphilis as it occurs in the neighborhood of the mouth and genitals, from impetiginous eczema due to pediculi, and from eczema seborrhoicum.

In syphilis about the mouth there are radiating fissures from the corners which extend to the mucous membrane, and mucous patches are often present on the lips and over the tongue. The separate papules and mucous tubercles about the anus, genitals, and buttocks of a syphilitic child could not be readily mistaken for eczema. The presence of snuffles and the bad general condition of the child would also usually distinguish syphilis.

A chain of enlarged lymphatic glands in the neck of a child with eczema of the scalp and neighborhood is almost a sure sign of pediculosis. With a little care the parasites or their nits can be readily discovered. The eruption of seborrhoic eczema in infants begins upon the scalp as a thick, moist, crusted patch on the vertex, which lacks the acute inflammatory characters of ordinary eczema. It may extend down on to the forehead and involve the region of the ears, but it rarely covers the centres of the cheek symmetrically and never presents thick blood-stained crusts. It likewise occurs around the umbilicus and in the groins. In the latter situation it may be distinguished from eczema intertrigo by its dull-red color, and especially by the fact of its presenting isolated papules beyond the border of the patch. Eczema seborrhoicum in this region shows more infiltration and inflammation at the periphery than in the crotch, while the reverse is true in eczema intertrigo.

In the *treatment* of infantile eczema it is necessary first to eliminate all possible sources of local irritation. If pediculi are present, the hair should be cut and the head soaked repeatedly in kerosene oil to destroy the parasites and nits. A three to five per cent. white precipitate ointment may be used for the same purpose. After these are removed the eczema is readily cured by the use of a two or three per cent. ichthyol ointment. In eczema intertrigo, it is important to have the diapers changed and washed frequently. The practice of reapplying them after hanging them up to dry is responsible for keeping up the disease in many cases. Dusting powders and cooling lotions are best suited to eczema in this locality. The calamine and zinc lotion or the magnesia and zinc lotion already referred to are of especial value in this type of the disease.

Every attention should be given to the feeding of the baby. If it nurses, constipation in the mother should be corrected and she should not be allowed to drink beer or spirits. If the child is bottle-fed the milk should be suitably modified according to the age and requirements of the patient. Patent foods, as a rule, should be prohibited, unless for some reason it becomes necessary to stop the milk. The other precautions referred to in the section devoted to the subject of diet should likewise be considered. For constipation in the child, castor oil is a very useful remedy; or a mixture of equal parts of castor oil, mistura cretæ, and water may be given twice or three times a day in teaspoonful doses. Calomel and soda, gr. $\frac{1}{10}$–$\frac{1}{2}$ of the former, with gr. iij.–v. of the latter, given in powder every second morning, is an exceedingly effective remedy in infantile eczema. Some cases, especially strumous subjects, do well under the following tonic: ℞ Liq. sodii arseniatis, gtt. ij.; tinct. nucis vom., gtt. x.; syr. ferri iodid., ʒ iss.; syrup. aurant. flor., ʒ iij.; Spts. mindereri, ʒ iss.; aquæ ad ℥ iij. M. Teaspoonful twice a day. In the local treatment every effort should be made to protect the inflamed skin and guard it from injury. The hands of the patient must be done up or encased in mittens to prevent its doing injury with the nails, and sometimes it is even necessary to confine the hands and arms to the sides. An ointment of salicylic acid and zinc, in strength of two per cent. of the former and six per cent. of the latter, smeared on two or three times a day, is often all that is needed. This may be advantageously alternated with the calamine and zinc lotion or with the ointment of calamine, camphor, and zinc already mentioned. When the inflammation has subsided, a mild tar ointment may be employed, or two or three per cent. of ichthyol may be added to the magnesia and zinc lotion. In all cases relapses are frequent and a cure cannot be safely promised until the child reaches two or two and a half years of age.

Parasitic Eczema.—We are in the habit of classifying as parasitic those sharply defined, moist, or crusted patches seen upon the lower legs accompanying varicose veins; the infiltrated, scaly, indolent, sharply defined patches which sometimes weep and become crusted and are situated in the flexors of the elbows and knees, and on the neck; and certain moist circumscribed patches occurring between the fingers, beneath the breasts, in the groins, axillæ, etc. A form of parasitic eczema occurs also in the corners of the mouth, resulting in cracks and a scaly out-lying patch, which is extremely obstinate and rebellious under any form of treatment.

No parasite has been demonstrated in these types of the disease, but they are regarded as due to parasitic infection from their general behavior, and because they yield only to strong antiparasitic treatment.

In parasitic eczema in general a paint of permanganate of potassium ʒ ss. to ℥ iij., applied twice daily, followed by a four-per-cent. ointment of powdered rhubarb with zinc, arrests the progress of the disease very promptly. In the indolent, infiltrated form ten per cent. chrysophanic acid in traumaticin (liquid gutta percha) is very effective when painted on once or twice a day. Five to ten per cent. pyrogallic acid in alcohol, used in the same manner, is likewise most efficacious.

Ichthyol used in a strength of from ten to twenty-five per cent. acts particularly well in that form which affects the corners of the mouth.

Eczema Seborrhoicum.—Seborrhoic eczema begins upon the scalp in the form of a pityriasis capitis or dry dandruff, which may remain in this state or develop into heavier masses of scales, forming what was formerly called "*seborrhœa sicca.*" After the disease has lasted some time upon the scalp, the hair becomes dry and brittle, loses its lustre, and finally atrophies and falls, producing partial or complete baldness. In some cases the eruption is distinctly oily in character, and the scales become agglutinated and form greasy crusts which adhere to the scalp. Beneath these is a red, smooth, moist surface which itches or burns slightly. The course of the disease is extremely variable, but sooner or later it spreads from the scalp to other parts sometimes remote, but often contiguous. In a more inflammatory form the disease spreads beyond the hairy border of the scalp, extending down on the forehead and temples and around the ears. This consists in an infiltrated, dull, yellowish-red band or patch of eruption with a sharp, slightly irregular outline and covered with yellowish, greasy crusts. In the lobes of the ears and the external auditory canal these dry into more or less thick flakes, which can be removed with the fingers, leaving only a superficial moist, red patch behind. Scaly, red patches appear in the eyebrows; and the central region of the face, base of the nose, alæ nasi, and the adjacent portion of the cheeks soon become involved in the process. Here the affected skin presents a rough, red, oily character which becomes more evident when the face is heated. As a rare condition the vermilion border of the lips is affected, resulting in great swelling, pain, and thick crusting. The beard and moustache rarely escape, the same red patches covered with greasy crusts being scattered through them.

Other favorite locations for the eruption are the front and back of the chest, especially between the scapulæ, in the axillæ and groins, and around the umbilicus. It may also occur on the arms and legs and in some cases spreads generally over the body.

On the chest and back the eruption consists of macules and discrete papules, dull red in color and slightly scaly, which slowly enlarge to form plaques or patches of various sizes. As these grow at the periphery, involution takes place in the centre, forming circular or circinate lesions, which by joining others form gyrate or festooned figures. This is the "*seborrhœa corporis*" originally described by Duhring.

In the axillæ and groins, and around the umbilicus the eruption generally occurs in the form of a sharply defined, yellowish-brown, slightly infiltrated patch which may become inflamed and crusted, resembling very much patches of ordinary eczema. Itching in seborrhoic eczema is not a marked symptom. Patients rarely complain of it except in warm weather, when they perspire freely.

When Unna first described this disease in 1887 he included many forms of eczema and even certain types of psoriasis under this name, but these generalizations have not been fully accepted. The best observers confine the title to the well-recognized types here described.

The disease is generally easily recognized. The chief reliance in diagnosis should be placed upon the seat of development, the method of progression, and the definite localizations of the disease, as well as upon the clinical appearances exhibited. The dull-red or yellowish-brown patches of crescentic or circinate outline, upon which soft greasy crusts form, can rarely be mistaken for the ordinary forms of eczema. In infants it lacks the symmetrical character and history of beginning on the cheeks and is never so inflammatory. From eczema intertrigo the differential points have already been given. The scales of psoriasis are dry and silvery white in color, the patches are more circular, and the localization of the eruption is different from that of seborrhoic eczema. Some cases of psoriasis, however, resemble eczema seborrhoicum very closely; in these the history and course of the disease will help to clear up matters.

That seborrhoic eczema is a parasitic disease is now pretty definitely established. Unna originally found diplococci in the lesions and several varieties of bacilli. One, which he called the "*morococcus*," he considered of special importance. He was unable, however, to reproduce the disease, but, through the bacteriological studies made by W. H. Merrill in 1895, Unna's findings were corroborated, and inoculation experiments were successful.

The *treatment* of the disease is not difficult. The most effective remedies are sulphur, resorcin, beta-naphthol, white precipitate and nitrate of mercury and also the bichloride. The biniodide and red oxide are likewise very effective in some cases. Upon the scalp a lotion of resorcin, of a strength of from three to six per cent. in equal parts of alcohol and water, acts promptly.

Sulphur, however, either alone or combined with resorcin, is the most reliable remedy we have. It may be used in an ointment containing five per cent. sublimed sulphur and two or three per cent. resorcin, or the resorcin may be used in a lotion, as already mentioned, and once or twice a week a five to ten per cent. sulphur pomade may be applied to the scalp. This should be done at night and the ointment washed off in the morning. A lotion containing gr. ij. bichloride, ʒ i. resorcin, ʒ iss. chloral hydrate, and ℥ iv. alcohol, is also extremely effective.

On the body a three or four per cent. resorcin ointment, or a mild sulphur ointment, will generally remove the trouble quickly. Beta-naphthol in five-per-cent. strength, white precipitate five to ten per cent., and the nitrate in about the same strength used in ointments, are all good and effective remedies. The biniodide may be used with the white precipitate ointment in the proportion of one or two grains to the ounce of a five-per-cent. salve. The ointment of red oxide of mercury and sulphur referred to under the treatment of eczema will be found of great service in this trouble. About the genitals in infants care must be taken not to use the remedies in too great strength.

ECZEMA OF THE SCALP.—Eczema manifests itself in various ways upon the scalp. In children and infants it appears more often as a vesicular or pustular affection, while in adults it is generally of the chronic erythematous or squamous variety. It may be limited to the scalp in both children and adults or may be only a part of a more generalized eruption. The pustular form of the disease as it occurs in infants and the impetiginous crusted eczema of older children, including the form associated with pediculosis, have already been considered. In adults the same clinical picture of pustular eczema is sometimes seen as that observed in children. It begins in the same way, in groups of pustules which generally dry without rupturing, forming patches covered with thick, dirty looking crusts. These may form anywhere upon the scalp and often coalesce into more extensive areas. The hair is matted down by the drying discharge and presents a most offensive and disgusting condition. This form usually occurs in poorly nourished subjects and in those who are neglectful of their persons. Itching, as a rule, is not complained of in this type of the disease, but sensations of soreness and burning pain are common symptoms.

The erythematous form of the eruption begins as a dry, red, scaly patch of variable size and outline, which grows slowly larger and becomes thickened and infiltrated. It soon runs into a chronic condition and in certain parts of the scalp, such as the hollow below the nucha, may remain for years resisting almost every form of treatment. These patches are very sharply defined, and there is so much infiltration that the diseased area projects above the natural level of the skin. Erythematous eczema may also spread over the scalp in an acute manner, with general redness, œdema, and sometimes vesiculation. The itching and burning in these cases are intense during the acute stage. Later, the disease becomes squamous in character and the affected skin is covered with dry furfuraceous scales.

The diseases most often confounded with eczema of the scalp are psoriasis, seborrhoic eczema, tinea favosa, and tinea tonsurans.

Psoriasis of the scalp presents about the same characteristics as when it appears upon the body; the patches never show moisture or soft crusts from the drying of a discharge, but are covered with dry micaceous scales or those of a thick imbricated character. The itching in psoriasis is not so severe as in eczema, and some evidence of the disease elsewhere is generally to be found.

The distinguishing features of seborrhoic eczema have already been given.

Tinea favosa may be mistaken for pustular eczema. The crusts of favus are sulphur yellow in color and not greenish or brown from the drying of pus, as in eczema.

The crusts of favus are cup-shaped and can be picked off, leaving a characteristic depression. The odor is distinctly mousy, and finally microscopical examination of portions of the crusts in favus will reveal the spores and mycelium characteristic of that affection.

In tinea tonsurans the spot affected is covered with broken, short, twisted hairs, having the appearance of being singed, or the spot is devoid of hair. Eczema does not destroy the hair in this manner. Patches of ringworm are circular and often devoid of any inflammation or redness, those of eczema are red and inflamed and usually of irregular outline. Ringworm of the scalp is confined almost exclusively to children, while eczema occurs in both children and adults. The microscope, as in the case of favus, would definitely determine any doubtful case.

In pustular eczema of the scalp ointments of iodol, europhen, ichthyol, and white precipitate are especially effective. Iodol and europhen may be used in a strength of half a drachm to the ounce of white vaseline, while ichthyol is most serviceable in a strength of from three to ten per cent. Five per cent. white precipitate is generally as strong as one can safely use.

For the chronic infiltrated patches occurring especially in the occipital region very vigorous treatment is generally needed. Salicylic acid, five to ten per cent., in alcohol; five per cent. of the same in diachylon ointment; six per cent. resorcin in equal parts of white precipitate and nitrate of mercury ointment; and unguentum picis et zinci are all useful in this condition.

In acute erythematous eczema, the tannin ointment referred to while discussing the local treatment of the disease, is the most useful remedy. Ointments of calomel, boric acid, and salicylic acid, and mild tar preparations will be found serviceable in the dry squamous types of the disease. In all cases the local treatment should be supplemented by the proper constitutional measures, if the best results are to follow.

Eczema of the Face.—The most common type of eczema of the face is the erythematous. It occurs in young, middle-aged, or elderly people, but is more frequently a disease of middle or advanced life. It is characterized by a dusky or bright-red, more or less diffuse eruption covering the cheeks, nose, eyelids, and forehead, stopping short usually at the border of the scalp and beard. The skin is swollen and at first smooth and tense; the eyelids are puffy, sometimes to the extent of complete closure; and when the disease is very acute, tiny vesicles develop upon the erythematous surface. Later in its course the disease loses its acute characters and assumes the aspect of a chronic process. It is accompanied by intense itching and burning; the skin becomes dry, scaly, and infiltrated, and the natural lines are exaggerated. Sometimes the itching is most intense, coming on in paroxysms, and the patient seeks relief by rubbing rather than by scratching. As a result of this the eyebrows are often rubbed off short, and the skin becomes steadily more infiltrated.

Eczema, as it occurs on the face of infants, has already been referred to and need not be further discussed in this place. Eczema of the face may occur as a part of a general eczema, in which case the entire face, including the ears, nose, lips, eyelids, cheeks, and forehead, is usually affected. These cases are generally chronic in character and are seen in the most typical form in strumous children. Erythematous eczema of the face is often mistaken for erysipelas and is often wrongly called "*chronic erysipelas.*" It is to be distinguished from that disease, however, by the absence of fever and general constitutional symptoms and by its very long and obstinate course.

In the acute form lotions of calamine and zinc, mild carbolic and boric acid lotions, the magnesia and zinc lotion previously mentioned, and dusting powders, are the most grateful kinds of applications. One or two per cent. of salicylic acid in gelanthum may be found of service in some cases. Ointments of oleate of zinc from half a drachm to one drachm to the ounce; of calamine, camphor, and zinc (formula already given); and of tannin and carbolic acid, may be advantageously used in alternation with the lotions.

In the chronic stage of the disease tar and mercurials may be used, first in moderate strength and later to produce their stimulating effects. The unguentum picis et zinci diluted one-half with zinc ointment; an ointment of two per cent. salicylic acid and three per cent. of ichthyol; oil of cade from half a drachm to one drachm to the ounce of simple ointment; and white precipitate ointment of a strength of from three to five per cent. will all be found of service.

As in the treatment of eczema of the scalp the constitutional measures employed in conjunction with those used locally are of the greatest importance.

Eczema of the Beard.—The disease in this region manifests itself in two fairly distinct types. It occurs as a superficial inflammation of the skin, with redness, swelling, moisture, and crusting, or it quickly goes deeper and invades the hair follicles. In the latter case each hair pierces a pustule, and when removed carries the root sheath with it, in the form of a swollen, succulent bulbous extremity. It also affects the skin between the hair follicles, and often extends beyond the hairy region. The disease is accompanied by much soreness and pain, though itching is most complained of by some. The hair is often very greatly thinned, but generally it is reproduced after the disease has been cured.

On the upper lip a similar condition may occur, the lip being swollen, red, and covered with thick dirty crusts. This results from an extension of the disease from the nares or is caused by the acrid discharge from a chronic nasal catarrh.

Eczema of the beard usually runs a chronic course and is very difficult to manage in most cases; in some instances it is only a part of a more general eczema and requires the same treatment as eczema elsewhere.

Eczema barbæ is chiefly to be distinguished from coccogenic sycosis. Ringworm of the beard, with its deep-seated nodular masses, can scarcely be mistaken for eczema. Sycosis begins primarily as a folliculitis and invades the hair follicle to its depth in a very short time, and is accompanied by papules and tubercles which are never present in eczema. Eczema is a superficial eruption and invades the hair follicles secondarily. Sycosis is confined to the follicles as a rule, while eczema invades the skin between and may extend beyond the hairy region. The hairs in sycosis are loose and can be removed without pain. Those in eczema cannot be extracted without giving considerable pain.

The *treatment* of eczema and of sycosis are about the same. In acute cases, the remedies used for eczema in general should be employed. As soon as possible attempts must be made to shave, and the face should be kept shaved; it must be done at least every other day. At first it is a very painful process, but after a while patients are able to accomplish it without causing much pain.

In some cases it is good treatment to epilate the hairs. When the hair is surrounded by pus it is better to remove it, for it only acts as a foreign body. General epilation may be necessary in very chronic and obstinate cases. Salves or pastes are generally more useful than lotions. Sulphur in a strength of from ten to twenty grains to the ounce is one of the best remedies. Dilute nitrate of mercury ointment, red oxide of mercury ointment (two drachms to the ounce of zinc ointment), three per cent. ichthyol ointment, oil of cade one drachm to the ounce, and from one to three per cent. oleate of mercury, are all to be especially recommended in this form of the trouble.

Other forms of tar, as thiol, pix liquida, etc., may also be used with benefit in some instances.

Eczema of the Auricles.—Eczema may attack the auricles independently of any other region, or may extend to them from the scalp and adjacent localities. It generally affects both organs and remains confined to them and is a disease which often recurs.

It is frequently dependent upon local causes, developing as a result of exposure to cold, harsh winds, of sunburn, frost-bite, etc. It is likewise sometimes due to the presence of pediculi or is caused by infection from chronic aural discharges. The eruption occurs in the erythematous, vesicular, or pustular forms, and though some cases are acute, lasting but a short time, the majority are extremely chronic and rebellious to treatment. The disease generally begins with burning or itching sensations, followed by redness and great swelling. Vesicles soon develop which by rupturing either keep the surface moist or through drying give rise to serous crusts. The ears are often so stiff and swollen that they stand out some distance from the head, and the least movement causes the skin to crack in the angle of junction with the head. These fissures bleed and become exquisitely painful, and from their natural location they are difficult to heal. In the chronic squamous form there is often much swelling of the external auditory canal, resulting in more or less deafness of a temporary character. The pustular type of the eruption is generally dependent upon pediculi, which must be discovered and removed before the trouble will yield. In the acute form the disease is sometimes mistaken for erysipelas, but its symmetrical distribution and general course, without constitutional symptoms, will always enable one to make the distinction.

The redness and swelling generally diminish rapidly under the use of the calamine and zinc lotion, or a lotion containing carbolic acid, gr. xv.; acid. borici, ʒ iss.; resorcin., gr. xx.; magnes. carbonat. and zinci oxidi, āā ʒ i. in four ounces of water. Dusting powders of talc and bismuth, or of stearate of zinc with salicylic acid, afford much relief in the acute stages. Mild ointments of bismuth, of boric acid, of oleate of zinc, and of calamine, camphor and zinc, are all useful in the treatment of eczema in this region. In the pustular forms, iodol ointment in three-per-cent. strength, three per cent. white precipitate ointment, or ichthyol ointment of a strength of two or three per cent., with or without two per cent. of salicylic acid, will be found of great service. In the chronic squamous variety tar is especially valuable, notably solutions and ointments of pix liquida. Ichthyol in a five-per-cent. ointment is most effective in healing fissures, but it is generally necessary to bandage the ears to the head. Where there is much swelling of the external auditory canal, glycerite of tannin diluted about five times with water may be applied with a brush once or twice a day.

Eczema of the Lips.—Fortunately eczema in this locality is not very common, for, on account of the natural movements of the parts and the close proximity to the saliva, it is extremely hard to manage.

The disease occurs here in the vesicular, erythematous, and pustular types, and is characterized by redness, swelling, heat, and thick crusting, which is sometimes serous but more often dark and blood-stained. The lips become very sore and stiff and rhagades form, not only at the corners of the mouth but at various points along the lips. The process is kept up by the picking the lips are subjected to by the patient in order to obtain relief, and by being kept wet with the tongue and saliva to relieve the dryness and burning.

The disease may be confined to the vermilion border and corners of the mouth, but in some cases it extends some distance beyond, and may even be continuous with a similar eruption in the nares. This latter is almost always associated with a chronic nasal catarrh, which is the cause of the eruption also upon the lips.

Eczema of the lips is sometimes confounded with herpes labialis, and in some instances, especially in children, resembles syphilis. Herpes is an acute affection consisting of one or more separate groups of vesicles, which dry into thin crusts that are soon thrown off. Eczema is never so localized, is slower in its progress, and presents symptoms of a more pronounced inflammatory type. Syphilis in this region is accompanied by radiating cracks at the corners of the mouth which are quite deep and secrete a puriform fluid. The fissures in eczema are more superficial and bleed easily. In syphilis there would usually be evidence of mucous patches in the mouth or on the tongue, and in children snuffles and other confirmatory evidence of the disease could doubtless be found.

In the *treatment* of this condition much tact and ingenuity are generally needed. In male adults, the use of tobacco in any form must be prohibited and hot or irritating substances kept away from the affected region. In acute cases soothing emollients are called for and often a simple protective will prove beneficial. Lassar's paste is one of the most useful applications in the early stages; it is thick, and acts as a good protection and its effect is slightly astringent and soothing. Hyde recommends a lotion of equal parts of tincture of benzoin, alcohol, and glycerin.

I have found a lotion containing sodium biborate, ʒ ij., glycerin, ʒ iv.; and rose water, ℥ iv., very useful in acute cases. Bismuth subnitrate, europhen, or oleate of zinc used in a tragacanth base, such as gelanthum, will also be found serviceable. The chronic cases often require very stimulating treatment with tar and potash solutions or by applications of nitrate of silver, chromic acid, etc. The fissures often heal rapidly after one or two applications of a silver-nitrate pencil.

Eczema of the Eyelids.—Both children and adults are affected with eczema of the lids. In children it generally occurs in strumous or ill-nourished subjects, while in adults it is frequently part of a chronic eczema in other regions. The disease attacks the free borders of the lids, which become red, swollen, and crusted. The hairs are affected early in the course of the disease, the inflammation extending to the depth of the follicle, producing a real sycosis of the lashes. The edges secrete a sero-purulent discharge which agglutinates the lids and sometimes sets up a conjunctivitis. The free border of the lids may also be the seat of a dry, squamous eczematous condition, which is devoid of much inflammation, but causes more or less annoyance in consequence of the itching. In chronic cases of the sycosis type the lashes loosen or are pulled out, the edges of the lids become quite hard, very red and either shiny or crusted, and the whole presents a very peculiar and characteristic deformity.

It is necessary to differentiate the disease from phthiriasis palpebrarum and from eczema seborrhoicum of the lids. In the former, examination with a hand-magnifying glass will discover the crab-louse, if present, clinging firmly to the base of the hair. In seborrhoic eczema there is no free discharge nor sero-purulent crusting and very little evidence of inflammation. The scales are yellowish and greasy and there is no agglutination of the lids. Evidence of the disease would also be readily found upon the scalp or other regions.

In acute cases, with much burning, redness, and swelling, the closed lids may be bathed with warm boric-acid solutions. Calamine and zinc lotion, applied by soaking small pieces of lint and laying them upon the lids, also acts in a very soothing manner.

In the crusted variety, the crusts should be soaked off with salicylated oil in a strength of two or three per cent., or they may be picked off, after which the application should be made. An ointment of yellow oxide of mercury, three grains to the drachm, may be used, or one of the red oxide diluted one to eight with cold cream. Another useful ointment is antimon. sulph., ʒ ss.; lanolin, ʒ ij.; vaselin. alb., ʒ iv. An ointment of one-per-cent. resorcin with two per cent. of salicylic acid, will also be found of value. Tannic acid, one drachm to the ounce of rose-water ointment, is often effective, or glycerite of tannin may be painted along the lids in a very weak solution.

Suitable constitutional treatment is necessary in all these cases.

Eczema of the Genitals.—Eczema frequently attacks the genital organs of both sexes, and in this locality probably produces more acute suffering than in any other part of the body. In the male either the penis or the scrotum or both may be attacked, but eczema of the scrotum occurs most frequently. In women the entire vulva is generally involved, including the labia majora, labia minora, vestibule and even the vagina. The adjacent region of the groins is likewise often affected. The erythematous, papular, or papulo-squamous types of the eruption are most commonly met with and it occurs in either an acute or a chronic form. Most of the cases which come for treatment have the disease in a chronic stage. The scrotum when acutely inflamed is red, hot, and swollen, the body of the penis and the prepuce are œdematous and as a result of rubbing and scratching there is more or less moisture and scaliness. In women, the labia are all much swollen, red and hot, and the whole vulva is moist and the parts are often agglutinated.

In some cases in both sexes the eruption is perfectly dry, there being no discharge, only erythema and scaliness accompanied by violent itching. In the chronic stage the scrotum is greatly enlarged, the skin is thickened, the natural lines are deepened and there are often fissures, excoriations, and crusts produced by violent scratching. The color is a very dark red or it may be of a purplish hue.

The penis, prepuce, and glans may be the seat of chronic eczema, the skin and mucous membrane being densely infiltrated, red, and crusted. In chronic eczema of the vulva the parts are often lacerated, greatly swollen, and thickened, and the vulvo-crural juncture is the seat of a moist red or crusted eruption. The itching in genital eczema is very intense and paroxysmal in character, and efforts at relief result in severe laceration of the tissues.

The disease is one of adult or advanced life and rarely occurs in children.

The dependent position, the heat and moisture natural to this region, and uncleanliness on the part of the patient are responsible for most cases of eczema in the male genital organs. When the glans and prepuce are affected with chronic eczema, glycosuria is often present and is the cause of the trouble.

In women, vaginal and uterine discharges, together with heat, moisture, and uncleanliness, are the most frequent causes. Glycosuria should also always be suspected in chronic eczema of the vulva. In making the diagnosis of eczema of the genitals, it is necessary to exclude pruritus, ringworm, and pediculi pubis.

The *treatment* in the acute stage consists in the use of cooling astringent lotions and dusting powders. When the scrotum is affected, a snugly fitting suspensory bag should be worn. Calamine and zinc lotion, and a lotion of magnesia and zinc with two per cent. ichthyol will be found useful. Boric-acid ointment, or the ointment of calamine, camphor and zinc, may also be used under these conditions.

Chronic eczema of the scrotum requires energetic stimulating treatment. Preparations of tar and mercury, both in lotions and in salves, will be found the most effective. Dilute liquor picis alkalinus, Vlemingkx' solution diluted to the extent of one to ten with water, equal parts of oil of cade or pix liquida and alcohol, three per cent. of salicylic acid with five per cent. of pyrogallic acid in alcohol, are all useful applications. A lotion containing magnesia carbonate and zinc oxide each ʒ i., sod. salicylat. ʒ iss., iatrol ʒ iss., and water ℥ iv., has proved useful in some cases. Applications of very hot water, for several minutes at a time, followed by a plaster of unguentum picis et zinci is a most valuable method of treatment. Tar and diachylon ointments and the various stimulating mercury ointments may also be employed. To reduce the thickening some use scarifications, galvanism, and paintings with liquor potassæ followed by the application of a soothing ointment.

Crocker treats the itching by placing a mustard leaf over the lumbar enlargement and gets better results than with anything else. Eczema of the vulva may be treated in about the same way, but the remedies must be a trifle milder. Dusting powders should be freely used in these cases in alternation with the lotions and salves mentioned.

ECZEMA OF THE ANUS.—The disease in this region is very slow in its development and is always a chronic affection. When well marked it causes much distress and general suffering, and in the worst cases is so wearing upon the system that the patients sometimes become nervous wrecks. The affected part presents a red, roughened, puckered appearance, the tissues are greatly thickened, there are often considerable moisture and exudation, and here and there excoriations from scratching. Painful fissures are likewise not uncommon, and these may extend beyond the sphincter; they cause much pain in defecation. The eruption may be confined to the anus or may spread forward on the perineum or posteriorly toward the sacrum. The itching is very intense and generally persistent, though it is always much worse at night. In their efforts to obtain relief the patients often severely lacerate the parts, thus sometimes causing free bleeding.

Eczema in this region must be distinguished from pruritus, which shows no visible lesions except perhaps a few excoriations from scratching.

Syphilis would always exhibit flat papules or mucous patches, it is devoid of itching, and other evidence of that disease would usually be elicited. Eczema ani may occur in children or in adults, but it is more common in the latter and of most importance in them on account of its obstinacy. It is sometimes caused by constipation and hemorrhoids, but is more frequently dependent upon a gouty condition. In children it is due to parasites and lack of cleanliness in the care of those parts.

In the *treatment* of this condition, constitutional and local measures are essential. Diet and hygiene are most important, as well as proper regulation of the bowels and treatment for the hemorrhoids if present. Alcohol and tobacco should not be allowed these patients, for they particularly aggravate the condition. Both soothing and stimulating remedies are generally necessary. For use in the daytime calamine and zinc lotion is effective, and at the same time convenient. At night a stimulating ointment should be applied, and tar in some form is particularly valuable.

It is in eczema of the anus that hot-water applications are so beneficial. They are best employed at night and in the following manner: Cloths are wrung out in very hot water, as hot as the patient can bear, and are firmly held against the part for several seconds, being renewed as fast as they cool. After several minutes of this treatment the salve selected is immediately applied. This should be spread upon lint beforehand so that the parts are not unduly exposed to the air in making the application. Unguentum picis et zinci employed in this manner is very efficacious. Ointments of ichthyol, oil of cade, or thiol may be used in the same way. An ointment composed of equal parts of belladonna and diachylon ointments has proved valuable in some cases.

Fissures should receive special treatment, either by dilating the sphincter or by means of local applications. Burning with nitrate of silver or caustic potash is often successful in healing obstinate fissures.

ECZEMA OF THE LEG.—In elderly people of both sexes eczema of the leg is a rather common affection. It is more common in the poor laboring classes than in those higher in the social scale. In younger people it occurs in this region as a part of eczema elsewhere, but in older subjects the eruption is usually confined to one or both legs, and may last for years without any other evidence of the disease manifesting itself. It occurs usually in the erythematous-papular type, beginning often in the region of the ankle, and forming one or more patches, which may slowly enlarge and eventually coalesce to form a larger area.

When the affection has lasted for a long time, most of the cases being very chronic, it is frequently found to involve the entire leg. It will then appear in the form of a continuous patch of eruption, characterized by redness, œdema or infiltration, weeping and crusting. Some cases present a smooth red, moist, glazed condition, the skin itself being greatly swollen or infiltrated. This constitutes the eczema rubrum already mentioned. In other cases the discharge becomes purulent and the reddened skin is covered here and there with greenish, foul-smelling crusts which upon removal leave a red, oozing surface. Many cases are associated with varicose veins, part of the leg being the seat of pigmentation of a brown or dark-yellow color, while in other portions, particularly around the ankles, eczema occurs, often surrounding the limb. Complications sooner or later arise in the form of ulcerations which, when once developed, are very sure to recur, especially if the varicose condition is well marked. Eczema never causes ulceration, but this is produced by bursting of the veins and breaking down of the weakened skin. Eczema verrucosum and eczema sclerosum, previously described, result from very long-standing cases in aged people,—cases which have been neglected or improperly treated.

The diagnosis of eczema of the leg is generally easy, the chief difficulty arising when ulceration, pigmentation, and scars complicate the disease. It is often very difficult to differentiate syphilis from an eczema thus complicated and in some instances it is quite impossible to do so. Syphilitic ulcerations, however, are usually multiple and occur most frequently in the middle or upper third of the leg. Scars from syphilis are generally thin, more or less round, and are surrounded by less deep pigmentation than are those which result from varicosities. Scars or other signs of the disease can often be found elsewhere. In women the history of miscarriages, still-births, etc., will help to confirm the diagnosis.

The treatment differs little from that of eczema in general, and many of the applications mentioned under local treatment in general would be applicable in this condition. Dusting powders, evaporating, cooling, and drying lotions, such as calamine, magnesia and zinc, etc., are indicated. When there is oozing and profuse weeping, Kaposi advocates the employment of dilute solutions of acetate of aluminum, to be applied on compresses, while Crocker uses solutions of the lactate or subacetate of lead in the same condition. Salves of boric acid, bismuth, salicylic acid, ichthyol, etc., should be employed after the excessive discharge has ceased. Lassar's paste is a most valuable remedy and the glycero-gelatin or the "Zinc-Leim" of Unna finds its chief usefulness in eczema of this region. Ichthyol, salicylic acid, boric acid, or any other medicinal agent, may be incorporated with it as the case may require.

Support of the sluggish circulation and varicose veins is of prime importance in the treatment of these cases. When the patients cannot rest the leg, the applications can be made by spreading the salve upon lint and laying it over the diseased area, after which the leg should be firmly bandaged from toe to knee. Dressings should be applied twice daily, the bandage being dispensed with at night. The Martin rubber bandage answers admirably in some cases. It should be applied directly to the leg before rising in the morning and at night it is given a good washing and hung up to dry. Some cooling astringent lotion is then applied and by morning the leg is ready for the bandage again. In some cases the pure rubber sweats the leg excessively and causes pustules to develop. In these, the elastic webbing bandage may be substituted.

Eczema of the Hands and Feet.—The eruption is found here in all its typical forms and all the primary types of lesion may be seen at one time or another in the different cases. Thus we may have erythema, papules, vesicles, and pustules, together with the secondary changes, as squamæ, crusts, infiltration, fissures, etc. The disease may be either acute or chronic. In acute vesicular eczema, the sides and flexor surfaces of the fingers or toes and also the palms and soles are the seat of small vesicles, sometimes deep-seated, at other times quite superficial. They are usually more or less grouped and in some cases coalesce to undermine sections of the skin with fluid. At these places the skin eventually peels off, leaving a red, new, thin skin, or one still eczematous, in which the disease presents the characters of a subacute or chronic squamous eczema.

Pustules may occur in the same manner on both the fingers and toes and palmar and plantar surfaces, in which localities they break or dry up into crusts, or form discharging patches. The erythematous, squamous, and papular forms of the eruption may affect the same regions, causing the skin to be dry, red, and scaly, and at the same time there are generally fissures at the flexures of the fingers, toes, or hands and also across the dorsal surfaces.

This type of eczema frequently affects the tips of the fingers, making them dry and fissured and very sensitive and painful at the slightest touch. Squamous eczema of the palms and soles occurs in small patches, scaly, red and fissured, or it may cover the part diffusely with the same dry, red, fissured eruption, extending even on to the dorsum of the member.

The *palms* and *soles*, from their special anatomical make-up, present features peculiar to themselves. The thickness of the horny layer determines the character of the lesions when the part is affected with eczema. The skin becomes thickened, hard, rough, and dry either in localized portions or diffusely. Sometimes true callosity exists, and from the great thickness and stiffness of the parts, deep, painful, and bleeding fissures generally develop. As in all the other forms of eczema of the hands and feet, one or both of the members may be affected, but generally the hands and feet are not affected at the same time.

The causes of eczema of the hands and feet are numerous. Many cases of acute vesicular eczema are dependent upon a gouty state of the system or upon a nervous, over-worked, or run-down condition. Eczema of the palms and fingers is often due to the occupation and constitutes in many cases examples of what is described as "*trade eczema*."

The diagnosis of vesicular or pustular eczema of the hands and feet is sometimes attended with difficulty. It often resembles scabies or the dermatitis produced by the poison ivy or poison oak. Scabies produces, as a rule, larger blisters which are more scattered, usually affecting all the fingers and especially the interdigital spaces. Eczema does not often involve all the digits, and the vesicles or vesico-pustules are more grouped.

The burrows of the itch mite can almost always be found by careful examination, and there would almost invariably be evidence of scabies in the other favorite sites for the disease. Dermatitis venenata, from the *rhus toxicodendron* or the poison oak, is very acute in its onset and course. It covers the hand and fingers and extends beyond them in a very short time, and similar irritative lesions quickly develop upon the face and genitals which would at once distinguish it. The history of exposure to such infection can often be readily obtained.

Syphilis resembles the squamous palmar and plantar forms of eczema very closely at times. Syphilis, however, begins as papules in the form of deep-seated or shotty, red nodules which are arranged in a circular or crescentic form. These coalesce to form a circinate patch, which spreads slowly over one or both palms or soles, even extending over the sides of the part affected. The fissures and scales which sometimes form are like those seen in simple eczema and can scarcely be distinguished from them; the diagnosis must rest mainly upon the method of evolution, the history and evidence of syphilis in other parts. Psoriasis of the palms and soles is so rare that to enumerate the diagnostic points is hardly necessary. It may be mentioned, however, that psoriasis almost invariably presents lesions elsewhere at the same time.

The treatment for acute vesicular or pustular eczema of the hands and feet is the same as that employed for the disease when it affects some other part of the body. Soothing and drying lotions, dusting powders, and protection from soap and water, from irritating substances used in the occupations, etc., are the measures indicated. In neurotic or gouty subjects the proper constitutional remedies, diet, hygiene, etc., should be instituted. In squamous eczema of the palms, soles, fingers, or toes, tar and the mercurials are particularly effective, though care must be taken not to employ them too strong. White precipitate ointment, citrine ointment, the red oxide and calomel ointments are all useful. For the fingers an ointment of iatrol, ʒ ss.; acid. salicylici, gr. x.; sod. salicylat., ʒ ss.; zinc. oxid., ʒ ss.; and gelanthum, ℥ i., is often effective.

Lassar's paste and Unna's zinc-gelatin paste, with or without ichthyol, are particularly valuable.

In palmar and plantar eczema the thickened epidermis should be first removed by the application of five to ten per cent. salicylic plaster or by means of pumice stone, or by the use of caustic potash, ten to fifteen grains to the ounce. If fissures are present these remedies must be used with care. After the calloused epidermis has been destroyed, ointments of salicylic acid, as the Lassar paste, and those containing thiol, oil of cade, ichthyol, pix liquida, or the various forms of mercury, should be used.

The fissures may be successfully treated by cauterizing with the nitrate of silver stick.

Eczema of the Nails.—One or several nails may be affected with eczema, but it rarely attacks all at the same time. Generally it concerns the finger nails alone, but occasionally some of the toe nails are simultaneously diseased. The symptoms are those dependent upon defective nutrition of the nail, and this in turn is due to changes in the matrix effected by the eczematous process. Eczema of the finger tips or of other parts generally accompanies the nail disease. The nail loses its lustre, becomes roughened and furrowed, is often distorted and greatly thickened, or it may be covered with small pittings, giving it a honeycombed or worm-eaten appearance. In some cases the nail becomes brittle and flakes off, while in others the thickened mass crumbles at the sides and tip, and gradually wears the nail away to a short stub. The nails are rarely shed entire, however, except in universal and very severe cases of the disease.

Eczema of the nails is to be distinguished chiefly from favus and ringworm and from psoriasis and syphilis. Scrapings from the crumbling portion of the nail, examined by the microscope in equal parts of liquor potassæ and glycerin, will reveal the fungus of favus or ringworm if present. Psoriatic and syphilitic nails show no distinctive differences in some stages from those affected with eczema. The physician must rely upon the history, upon the presence of other lesions than those of the nail, and upon the general course of the disease in either case.

The effect of treatment in eczema of the nails is slow. General tonics of arsenic, iron, cod-liver oil, etc., should be given continuously; arsenic alone has but little effect upon the disease. Locally, the nails should be scraped and dipped into extremely hot water for ten or fifteen minutes every night, after which they should be done up in some ointment or oily preparation. The oleate of mercury, five to ten per cent., Hebra's diachylon ointment, the unguentum picis et zinci, the white precipitate or the nitrate of mercury ointment,—any one of these may be used for this purpose. I have found an ointment of resorcin, ℈ij.; stannic. oleat., ʒ ss.; lanolin., ʒ ij.; and ungt. aquæ rosæ, ʒ vi., of much service in treating eczema of the nails.

In all cases it is advisable to protect the nails with finger cots during the day, whether or not it may be possible to keep an application upon them.

Henry H. Whitehouse.

EGG, YOLK OF.—Vitellus, U. S. P. The egg of the common fowl, *Gallus Bankiva domesticus* Tern., can hardly be said to be a medicine, although admitted to most pharmacopœias for one purpose or another. Its shell was formerly used as a form of lime salts like oyster shells, coral, etc., but it is now obsolete. The white of the egg, *Ovi Albumen*, is a source of albumen for pharmaceutical and chemical purposes (estimation of pepsin, clarification of solutions, etc.), and a useful antidote to poisoning by corrosive sublimate. It is composed of twelve or fourteen per cent. of pure *albumen*, and eighty-eight or eighty-six of water, with traces of salts, etc. The yolk, which alone is official here, is a bright yellow mixture of about sixteen per cent. of *vitellin*, a substance resembling albumen; forty-three hundredths of a per cent. of *cholesterin;* three-tenths of one of *cerebrin;* eight and a half of *lecithin*, a fat-like nitrogenous substance containing also phosphorus; one of *glycerin acids;* twenty-one of *palmitin* and *olein;* a number of saline substances; coloring matter; and, finally, fifty-one of water (Gobley, quoted by Hager). Yolk of egg has considerable emulsifying power for oils and resins, and is official simply on that account. A mixture with glycerin (*Glyceritum Vitelli*, U. S. P.), "*glyconin*," consisting of yolk of egg forty-five and glycerin fifty-five parts, is permanent and very useful in this way. Cod-liver, castor, and other oils, besides some resins and other insoluble substances, are well suspended by it. An egg beaten up alone or with milk, or digested artificially, makes an excellent nutrient enema when such method of feeding is necessary.

W. P. Bolles.

EGOLS are a class of stable mercury compounds introduced by Gautrelet. They are brown-red powders, crystallizing in rhombahedra with difficulty, and easily soluble in water. Their solutions are odorless, tasteless, neutral, and non-irritant, and possess marked bactericidal properties. They are said to precipitate toxins, but not to coagulate albumen.

Phenegol, the best known, is the potassium nitro-phenol-para-sulphonate of mercury $(C_6H_3NO_2.\ SO_3K.O)_2Hg$. It contains thirty-three per cent. of mercury, is said not to attack metals but in 0.4 per cent. solution to kill all bacteria, and is claimed to be a valuable substitute for mercuric chloride.

The cresol compound is called *cresegol*, and the thymol preparation, *thymegol*.

W. A. Bastedo.

EGYPT.—This country, long known as a winter sanitarium, illustrates the dry warm desert climate, resembling that of Arizona, New Mexico, and portions of Texas and California in the United States. The main characteristics of the climate are: (1) *Warmth*, the mean temperature of Cairo for the winter months being 58.3° F. (2) *Large diurnal variation*, the difference between day and night temperatures varying from 35° to 19° F. (3) *Dryness of atmosphere* and *small rainfall.* "Six rainy days only in five months were chronicled at Assouan in 1892–93." The difference between the wet and dry bulbs sometimes amounts to 24° F., and the annual relative humidity varies from 58.4 per cent. at Cairo to 45 per cent. at Luxor. (4) Almost *continuous sunshine.* (5) Great *purity of the desert air.* "Meat exposed to the air becomes mummified in three weeks without any trace of decomposition." The general effect of this climate upon the individual is bracing, and at the same time sedative to the nervous system.

The resorts generally frequented by invalids, especially by the tuberculous, are Gizeh (The Mena House), Helouan, Luxor, and Assouan. There should also be mentioned the Nile voyage and camping out. Cairo is to be avoided by the invalid for any lengthy stay, for no large crowded city, even if it possesses the best possible climate, is to be recommended to an invalid, and, further, the sanitary condition of Cairo is not good, and the portion occupied by the European settlement is built upon what was once a swamp and is still in parts swampy. "Moreover, the country around Cairo is most thoroughly irrigated, and the exhalations from the moist land after sunset are extraordinary."* Since the occupation of Egypt by the English, everything has been established upon a more orderly and stable basis, and doubtless the influence of this is felt, even in the health resorts, in greater attention to the sanitary conditions. The season for visitors extends from October or November to the first or middle of April. Before considering in detail the resorts mentioned and the other means of utilizing the climate, it will be well to discuss the climatic elements, their advantages as well as disadvantages, and for this purpose the following simple chart has been compiled from various sources:

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* Solly: "Medical Climatology."

Climate of Egypt. Observations Mostly Taken at Cairo.

Data.	October.	November.	December.	January.	February.	March.	For year.
Temperature (Fahr).—							
Average or normal..	74.3°	64.4°	58.4°	53.6°	57.0°	62.8°	70.2°
Average daily range.	19.2	17.9	17.3	14.8	16.5	20.2	19.7
Mean of warmest ...	84.0	74.2	67.7	61.4	65.3	73.2	80.1
Mean of coldest......	64.8	56.3	50.4	46.6	48.8	53.0	60.4
Highest or maximum	During 1888 the absolute maximum reached was 111.8° on July 13th. In 1887 it was 110° on June 9th.						
Lowest or minimum	In 1888, the absolute minimum was 36.4° in January. In 1887 it was 35.2° in January.						
Humidity—							
Average relative	65.8%	67.5%	69.6%	69.7%	66.2%	56.2%	58.4%
Average absolute....	.52	.39	.33	.28	.29	.29	.40
Precipitation—							
Average in inches ...	....	.21	.19	.19	.24	.03	1.22
Wind—							
Prevailing direction.	N.	N.	N.	S. W.	N.	N.	N.
Average hourly velocity	3.2	2.1	2.2	2.2	1.4	2.5	2.9
Weather—							
Clouds (0–10)........	2.5	3.0	3.7	4.1	4.2	3.4	2.6

"In a total of 1,083 observations made during the course of three years, the sky at Cairo was found to be cloudless 709 times; clouds were obtained 254 times, an overcast sky was seen 95 times, and a truly cloud-covered sky was recorded on only 25 occasions." *

In the desert and at Luxor clouds are almost unknown.

At Cairo, during the winter months, there are only from twelve to fifteen days upon which rain falls.

At Luxor rain is a very rare phenomenon.

During five months at Assouan, in the winter of 1892–93, there was blue sky on all but fifteen days.

The most remarkable feature of the Egyptian climate is considered to be the peculiar dryness of the atmosphere, rendering the air bracing and tonic. The relative humidity at Cairo for the year is 58.46 per cent., and for the seven winter months it averages 63.25 per cent. At Gizeh and Helouan it is considerably lower, and still more so at Luxor and Assouan, it being 50.5 per cent. at Luxor.

There is almost complete absence of rain. At Cairo the annual rainfall is 1.22 inches, and the number of rainy days during the winter season (seven months) is twelve. At Luxor there usually is no rain.

"Unless it be in southern and southwestern Arizona, no portion of the United States can be compared with Egypt in the matter of cloudlessness of sky; and it is hardly necessary to add that no such freedom from clouds exists in any part of Europe. This circumstance, taken in connection with the mildness of its day temperature, even in mid-winter, and the comparatively long duration of the hours of possible sunlight (depending upon its southern latitude), marks the whole country of Egypt, and particularly its more southern portion, as that region of the world affording perhaps the best facilities to the invalid desiring to pass as much time as possible in the open air during the cold season of the year. The hours of possible sunshine are much longer in Egypt than in Davos or the Engadine, longer than in Colorado, and even longer than in Southern Arizona; the intensity of the sunlight, especially in Upper Egypt, is probably as great as at any of these places (although we have no data at hand to prove that such is the case); the purity of the atmosphere in respect to the presence of germs, outside of the towns, is probably not far inferior, even in the Nile valley, to that of Colorado, Davos, or Arizona; while in the desert proper it is quite as great. The temperature during the day is higher without being, as a rule, excessive; while by night it is also higher, and, although abundantly cool to be invigorating, is, nevertheless, not more contrasted with the day temperature than is the case in Arizona, Colorado, or Davos. Rain is less frequent than at Davos or in Colorado, and is as infrequent as in Southern Arizona, even at Cairo; and, owing to the absence of clouds, the actual number of hours of sunshine coincides more nearly with the possible number of such hours than is the case in Colorado, Davos, or Arizona. Winds in Egypt are of more frequent occurrence than at Davos during the winter, but probably no more so than in Colorado or in Arizona; while in point of velocity they are probably not higher than in Colorado, although higher than at Davos, and perhaps higher than in Arizona. Absence of statistics prevents an accurate comparison of these resorts in this respect. Violent hot winds, laden with sand from the desert, and exerting a very debilitating influence not only upon men, but also upon animals, occasionally blow in Egypt during the latter part of the winter season. These winds come from the south, and seldom begin to blow before the middle of February; indeed, their time of most frequent occurrence is during a period of fifty days after the vernal equinox, to which circumstance they owe their name, Kamsin. The Kamsin blows, on the average, at Cairo only upon eleven days out of the whole year. The rapid and extreme rise of temperature produced by one of these winds, occurring on May 31st, 1857, is instanced by Dr. Hann on page 443 of his "Handbuch der Klimatologie." The drying effect of the wind is also shown in the figures quoted by Dr. Hann, which figures are given below.

Kamsin of May 31st, 1857, at Cairo.

Hour.	Temperature.	Relative humidity.	Wind.
7 A.M	78.08	54	Calm.
10:30 A.M....................	100.76	19	S.S.W.^{2}
Noon.........................	103.64	12	S.S.W.^{2}
2 P.M........................	105.62	15	S.S.W.^{3}
9 P.M........................	95.18	13	Calm.
11 P.M.......................	91.4	19	Calm.

"The small figures appended to the letters S.S.W., showing the direction of the wind, probably indicate the velocity *in metres per second*, a velocity which would be equivalent to 4.47 miles per hour at the hours of 10:30 A.M. and noon, and to 6.71 miles per hour at 2 P.M. Even if these figures are intended to mark the velocity of the wind according to the scale in which 0 represents a calm and 10 a violent hurricane, it is evident that the force of this particular Kamsin wind was not particularly great. At Cairo, the prevailing direction of the wind during the months of January, February, March, and April is stated by Dr. Kisch (Eulenburg's "Real-Encyclopädie") to be as follows: January, northeast; February, northwest; March, west; April, north. Of the winds at Cairo, Dr. Rotureau ("Dictionnaire Encyclopédique des Sciences Médicales") speaks as follows: "The east wind is almost the only one which blows at Cairo during the months of January and February; it lasts from ten o'clock in the forenoon until sunset, and it is against its freshness, often very considerable, that invalids walking out of doors should especially protect themselves. When the east wind is violent, it is almost impossible to go out of doors on account of the clouds of dust which it raises, and which it causes to penetrate even into the most tightly closed apartments. Such a violent easterly wind, however, seldom occurs at Cairo on more than six or eight days out of the whole year. Winds from the northeast, north, and northwest sometimes blow, but never last long enough to be dangerous (n'existent jamais assez longtemps pour être dangereux). The Kamsin, or south wind, does not occur at Cairo until after the middle of February; . . . occasionally (however) it appears earlier," etc. The following quotation respecting the winds of Egypt is taken from the article on "Egypt" in the "Encyclopædia Britannica."

"The wind most frequently blows from the N.W., N., or N.E., but particularly from the first direction. The proportionate prevalence of these winds to those from all the other quarters, in the year, is about 8 to 3; but to those from the S., S.E., and S.W., about 6 to 1. (Clot-bey, "Aperçu Général sur l'Egypte," i., p. 30.) The northerly winds are the famous Etesian winds of Herodotus (ii., 20), which enable boats constantly to ascend the Nile against its strong and rapid current, whereas in descending the river they depend on the force of the stream, the main-yard being lowered. These winds also cool the temperature during the summer months. The southerly winds are often very violent, and in the spring and summer, especially in April and May, hot sand-winds sometimes blow from the south, greatly raising the temperature and causing especial suffering to Europeans." Several other special winds are also mentioned in this article in the "Encyclopædia Britannica," but none of them requires mention in this place.

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* Lombard, quoted by Richards.

"Finally, it should be remarked that a morning fog is a not infrequent occurrence along the banks of the Nile; but such a fog never lasts more than a few hours, being quickly dissipated by the heat of the Egyptian sun.

"On account of the rapidly increasing heat of the spring season, and the especial frequency of occurrence of the Kamsin at that season, it is not desirable that invalids should linger in Egypt later than the month of March, and preferably not later than the middle of this month; owing also to the great heat during the early autumn, and to the prevalence of malarial fevers at that season, it is not well for the invalid to go to Egypt before the middle of November, and for such as intend to make the Nile journey, the middle of December is abundantly early to start. Consequently we see that the season for invalids in Egypt is a comparatively short one, quite as short as at Davos, and considerably shorter than in Colorado. For residence all the year round Egypt is not at all well suited, the summer and autumn heat being far too oppressive. As a sample of the degree of heat which may be experienced in the autumn, it may be of interest to remark that a temperature of 103.5° F. was observed at Alexandria on October 11th, 1877, being the maximum temperature for that whole year, and that the month of October is generally warmer than May at that place, while September is nearly as warm as June (Hann, *op. cit.*, pp. 422, 423)." (Huntington Richards.)

During the season in Egypt (October to April) we see from the climatic table that there is no great variation of temperature from day to day, or indeed from month to month, during the five months from November to March. The daily range, however, is great, and there is a very marked contrast between the day and the night temperature, caused by the rapid radiation of heat after sundown from the sands of the surrounding desert.

"Unlike the more irregular falls of temperature, which occur with greater frequency and are apt to be of greater severity in European countries and in a large part of the United States (the land of "blizzards" and "cold waves"), these nightly falls of temperature in Egypt may in great measure be guarded against by the invalid, especially if he have taken up his residence at Cairo. Greater precautions are of course necessary to the invalid who is making the Nile journey on board of a dahabeeah, or who has determined to pass the winter living, like the Arabs, in a tent upon the desert. Flannel underclothing should be worn by all visitors to Egypt, and a supply of warm outer clothing and of wraps is necessary as well, especially for those intending to make the river trip, or to convert themselves temporarily, for the benefit of their health, into amateur Bedouins. Not only is it the decided fall of temperature after sunset against which the invalid must be on his guard, but in addition to this (and depending partly upon it and partly upon the moderate humidity of the Nile valley), the precipitation of dew is very abundant, at least in all portions of Egypt lying in close proximity to the river and its bordering tract of arable land." (Huntington Richards.)

The drawbacks of a winter in Egypt, as indicated by Dr. Bentley of Cairo,[*] are (1) that invalids do not consult a physician until they are attacked with a serious illness. (This drawback unfortunately is not confined to the Egyptian climate.) (2) Ignorance of most invalids as to the nature of the climate to which they resort and apparently the want of appreciation of the real object for which they go abroad. (It is a question if this ignorance is not rather to be ascribed to the home physician.) (3) Opportunities which exist of sightseeing and social gatherings with their attendant evils—over-fatigue, over-crowded rooms, and late hours. (4) Occasional cold high winds, and at times unreliable weather. (5) Sudden and sometimes marked fluctuation of temperature between day and night, sunshine and shade. (6) Hot winds (Kamsin) which commence in February, blow for about two days at a time, and are accompanied by fine particles of sand suspended in the air.

As has been said, Cairo should not be selected by the invalid for a lengthy sojourn. If, however, one is simply desirous of rest and diversion, and is otherwise well, he will find innumerable ways of amusing and forgetting himself in this great Oriental city. For the true invalid, however, and especially for the tuberculous patient, the noise, dust, and attractions of Cairo are to be avoided by selecting either Gizeh, Helouan, Luxor, or Assouan, or by taking a voyage up the Nile, or by camping in the desert. At Gizeh, eight miles from Cairo, is the English hotel, Mena House, on the edge of the desert, affording first-class accommodations, with a resident physician and chaplain, a swimming bath, and arrangements for tennis, croquet, and golf. "The invalid spends his time in the desert, enjoying its invigorating air from morning till night. He may find rest, almost complete immunity from rain, and unlimited sunshine. It is an invaluable health resort for those who wish to avoid the fatigue and expense of the journey up the Nile."[*] In December and January the winds are said to be often cold here, and the changes of temperature sudden and great, so that one must be provided with warm outer garments. After sunset, the cold, by comparison, seems severe, and one must be careful to avoid a chill. The temperature is practically that of Cairo, and the humidity lower.

Helouan is fourteen miles by rail from Cairo, situated in the desert, and contains two large and comfortable hotels, numerous *pensions*, and houses for rent. It is said to have a remarkably dry and sterile atmosphere, and has become not only a favorite locality for invalids but a residential suburb of Cairo. There are hot sulphurous springs at Helouan which "have long enjoyed a reputation for chronic rheumatic affections." The baths are well constructed and resemble those at Aix-les-Bains.

Luxor, four hundred and fifty miles from Cairo, at the first cataract of the Nile, is reached by rail from the latter city, or one can take the slower method of river navigation. It is dryer, warmer, and sunnier than any of the resorts about Cairo; "several winter seasons often pass without a shower" (Thompson). The following table from Sandwith gives the climatic details:

CLIMATE OF LUXOR FOR THE WINTER MONTHS.

Data.	November.	December.	January.	February.	March.
Temperature (deg. Fahr.).					
Average or normal	....	....	56.7°	62.6°	66.9°
Average daily range....	....	....	23.7	31.7	38.4
Mean of warmest	78.9°	70.6°	65.1	70.6	80.1
Mean of coldest.........	62.1	53.6	41.3	42.4	47.6
Highest or maximum ...	94.0	77.0	83.0	86.0	110.0
Lowest or minimum....					
Humidity—					
Average relative........	....	....	53.2%	51.0%	45.0%
Precipitation—			(Not kn	own.)	
In inches	Minut	e fracti	on of an	inch, if	any.
Wind					
Prevailing direction	S. W.	N. E.	N. W.	N. W.	N. W. N. E.
Average hourly velocity.	0.1	1.8	1.0	1.1	0.7
Weather –					
Clouds (0–10)	....	....	2.9	1.9	2.1

"The sky was noted as being completely overcast four times in January, once in February, and three times in March."

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[*] British Medical Journal, December 8th, 1894, p. 1300.

[*] Thompson, "The Climate of Egypt," The Practitioner, 1895.

December, January, and February are considered the most available months for Luxor. The town has four thousand inhabitants, with two good hotels and English physicians. "The invalid should not leave the house before 10 A.M. or remain out after sunset." During these three months the bedroom temperature is generally above 63° F. As seen from the table the daily range of temperature is great. The drinking-water, as is generally the custom, comes from the Nile and is filtered. There is much of interest in and about Luxor in the many Egyptian ruins and antiquities.

Assouan is 133 miles higher up the river than Luxor, 583 miles south of Cairo. Besides being warmer than Luxor, its climate is about the same, although the air is said to be freer of dust storms. There is a large and comfortable hotel here, and as rain never falls, the roofs are carpeted, with easy chairs in the shady corners. The air is so dry that the heat is not uncomfortable, and the same clothing is recommended to be worn as in an English winter. Here, as elsewhere, the cool night air is to be avoided.

The Nile voyage is best made between November and March, and one can make the journey either by steamer or dahabiyeh; the latter method is of course the most enjoyable, and weeks may be occupied in making it. The steamers have at least one advantage, that of carrying a physician. "If there is anything in life," says Peterson,* "which will steal away worries and cares, soothe the tired brain, calm the unstrung nerves, bring back vagrant sleep, it is the dream-like voyage on the Nile in a dahabiyeh." For an invalid, however, particularly if he is suffering from throat or lung trouble, this delightful journey is not without its risks; for the nights are cold and frosty, the mists cover the river in the early mornings, and the wind is sometimes strong and "dangerously cold for an invalid."

Camping in the desert, when this method of life is available, is perhaps the most effectual means of utilizing the advantages of the Egyptian climate. "Our experience of treatment," say Weber and Foster in Allbutt's "System of Medicine," 1896, "by continued residence during several entire years in the Nubian desert under tents shifted from one place to another, has, in several advanced cases of consumption, given results which are altogether superior to any obtained from any health resort or from any other treatment." "Camp life in Egypt," says Peterson (*loc. cit.*), "is something luxurious. Labor and carrying cost next to nothing, and everything in the way of furniture and supplies can be stored away somewhere on a canal. Every day can be foreseen to be rainless and beautiful; life in tents becomes a pleasure."

The diseases for which the Egyptian climate is to be recommended are: (1) Phthisis in the early or advanced cases, if the conditions are not acute; hemorrhagic cases; cases associated with bronchitis. Benefit is said also to be obtained in the first, second, or third stage of the disease, if not acute, especially when the origin of the affection was pneumonic, broncho-pneumonic, or pleuritic. Both C. T. Williams and Sandwith give series of cases with fairly favorable results. (2) Chronic bronchitis and emphysema; asthma. (3) Rheumatism and rheumatic arthritis. (4) Bright's disease and albuminuria. (5) Chronic nasal and pharyngeal catarrh and deafness dependent upon abnormal conditions of the Eustachian tube. (6) Convalescents from pneumonia, pleuro-pneumonia, and pleurisy, and various acute specific diseases. (7) Neurasthenia and cases of mental strain and breakdown. (8) Atheroma and arteriosclerosis. (9) Hemiplegia and paresis. (10) Anæmia. (11) Heart disease. (12) The old and prematurely aged. (13) Neuralgias.

The cases for which this climate is contraindicated are: (1) Intestinal ulceration, chronic dysentery, or any tendency to diarrhœa. (2) Well-marked diabetes. (3) Laryngeal ulcerations. (4) Rapidly advancing and active phthisis. (5) Tuberculous kidneys.

"The advantage of the Egyptian climate in the treatment of phthisis lies in the warm sunny days, the dryness of the atmosphere, and the aseptic character of the air. Its drawbacks are: the short time of year during which it is available, and the danger of contracting chills, chiefly abdominal" (Weber and Foster, Allbutt's "System of Medicine"). The hygienic-dietetic treatment of phthisis in a well-conducted sanatorium, in almost any temperate climate, where pure air, sunshine, and freedom from dust and wind can be obtained, would probably give a much higher average of favorable results; for the treatment could be continued until the cure had been effected, without change of locality, and, what is of vital importance, the patient would be under constant medical supervision, and would be kept up to the strenuous work of getting well.

The expense of living and travelling in Egypt is greater than in most European countries, but probably no greater than in the United States for the same accommodations, if as great. One can now take a steamer from New York and go directly to Alexandria, or go from London, Plymouth, Marseilles, Naples, Genoa, or Venice. The steamers from New York to Genoa, Naples, or Alexandria are large and comfortable, and going by the "southern route" the voyage is likely to be a smooth one.

For further consideration of the climate of Egypt, one is referred to "Egypt as a Winter Resort," by F. M. Sandwith of Cairo, 1889.—"The Climate of Egypt," by E. Symes Thompson, M.D. *The Practitioner*, 1895, vol. lv., p. 532.—"Notes on Egypt as a Health Resort," by P. Watson Williams. M.D. *Bristol Medico-Chirurgical Journal*, 1895, vol. xiii., p. 262.—"Wintering in Egypt," by Frederick Peterson, M.D. *Medical Record*, 1892, vol. xlii., p. 205.

Edward O. Otis.

EHRLICH DIAZO REACTION. See *Typhoid Fever.*

EIGON is a name given by Dieterich to a series of albumin and iodine compounds of constant composition.

Alpha-eigon (albumin iodatum) is an odorless, tasteless, light-brown powder, containing twenty per cent. of iodine, which is set free by alkalies and more readily by acids.

Alpha-eigon-sodium (sodium iodo-albuminatum) is nearly colorless, odorless, almost tasteless, and readily soluble in water. It contains fifteen per cent. of iodine, and in four or five times the dose is used to replace potassium iodide.

Beta-eigon (peptonum iodatum) is a compound of fifteen per cent. of iodine with predigested albumen (peptone), designed for the easy ingestion of large quantities of iodine in the presence of gastric disturbances. Administered in malt extract, wine, or cod-liver oil, these substances have been used internally in place of iodides in syphilis, scrofula, furunculosis, etc. After long use in large dose, no symptoms of iodine intoxication supervened. Externally, in wounds, boils, and venereal ulcers, Tischer and Beddies found them more effective than iodoform, and preferable on account of the absence of odor. They use it in ten to thirty per cent. strength, diluted with talcum powder. The internal dose is 1 gm. (gr. xv.) three times a day, gradually increased.

W. A. Bastedo.

EKA-IODOFORM is iodoform prepared by electricity and mixed with 0.05 per cent. of paraform. It does not decompose in ethereal solution, but in contact with the tissues generates gaseous formaldehyde. It is recommended as a succedaneum for iodoform.

W. A. Bastedo.

ELASTICA.—See *Rubber.*

ELATERIN.—ELATERINUM.—"A neutral principle obtained from elaterium, a substance deposited by the juice of the fruit of *Ecballium Elaterium* (L.) A. Rich. (fam. *Cucurbitaceæ*)," U. S. P.

This, the wild or squirting cucumber, is a small perennial or, in temperate climates, sometimes annual herb, with a fleshy, tapering root, and succulent, prostrate, cucumber-like stems. The fruit, which is also official in some countries, where the plant grows, is from three to six centimetres long, by one or two in diameter (1 to $2\frac{1}{4}$ in. by $\frac{1}{3}$ to $\frac{2}{3}$ in.), oblong, ovoid, covered with fleshy, tapering, soft bristles, and of a yellowish-green color. Texture firm externally, but soft and very watery in the middle. At maturity the tension produced by the accumulation of liquid within the pericarp becomes so great as to burst the fruit at the base, forcing off the peduncle, with a squirt of the soft contents, seeds and all, to a considerable distance. From this peculiar mode of distributing its seeds the plant has received its name (ἐκβάλλω). The seeds are numerous, compressed, ovoid, smooth, brown; they also were formerly employed.

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* Medical Record, August 20th, 1892.

This plant is indigenous to Persia, India, and the warmer Mediterranean countries. It has also been naturalized and cultivated in various parts of Europe. It is raised in England and elsewhere for medicinal use. It is a very old medicine, having been mentioned before the Christian era.

The fruit, for medicinal purposes, should be gathered just before it is wholly ripe, and, of course, before it has expelled its contents. It is used to prepare the crude and impure elaterin, which has been long known as *Elaterium* (B. P., also U. S. P. of 1870), and is still the more common article in the markets.

Elaterium.—This is a precipitate which forms spontaneously in the liquid juice of the ecballium fruits, and is collected as a sediment from it. The purer and clearer this juice, therefore, the better the precipitate. There are several ways of collecting it, two of the best being as follows: The British Pharmacopœia formerly directed to "Take of the squirting cucumber fruit, very nearly ripe, one pound. Cut the fruit lengthwise, and lightly press out the juice. Strain it through a hair sieve, and set it aside to deposit. Carefully pour off the supernatant liquid; pour the sediment on a linen filter, and dry it on porous tiles in a warm place. The decanted fluid may deposit a second portion of sediment, which can be dried in the same way." Dr. Clutterbuck saved the juice of the sliced fruit, and then scooped the soft pulp out with the thumb, threw it upon a sieve to drain, and washed it with water without pressure. These liquids were set aside, and the precipitate collected and dried as above. This method produced a very fine quality of Elaterium, which has been famous for more than half a century. Elaterium appears to be good in proportion to the near approach to ripeness of the fruit used, and to the absence of pressure in manipulating it. The continental grades of this article are generally inferior to the English, whose properties are thus given in the British Pharmacopœia:—"In light, friable, flat, or slightly curved opaque cakes about one-tenth of an inch (2.5 mm.) thick; pale green, grayish-green, or yellowish-gray; fracture finely granular; odor faint; tea-like; taste bitter and acrid. It should not give the characteristic reactions with the tests for carbonates or for starch, and should yield half its weight to boiling alcohol (ninety per cent.). When exhausted with chloroform, the solution evaporated, the residue washed with ether, and the process of solution, evaporation, and washing repeated, elaterium should yield twenty-five per cent., or not less than twenty per cent., of elaterin."

The poorer, German elaterium, comes in thicker (about $\frac{1}{4}$ in.) cakes, largely wanting in the green color and sparkling appearance. It is about one-fourth as strong. The yield of the fruit is about 0.123 per cent. of elaterium. Besides the active principle, coloring matter, cellular tissue, starch, ash, and water make up the rest.

ELATERIN.—Discovered by Morries and Hennell, 1831. The most scrupulous care must be taken not to confuse the dosage of this powerful poison with that of the weaker substance described above. This crystalline substance has been adopted by our Pharmacopœia, to the exclusion of elaterium, in consequence of the very uncertain quality of the latter drug. It is also official in Great Britain.

It is a definite chemical combination of the formula $C_{20}H_{28}O_5$, and is thus described in our Pharmacopœia:

Minute, white, hexagonal scales, or prismatic crystals, without odor, and having a slightly acrid, bitter taste; permanent in the air.

Soluble, at 15° C. (59° F.), in 4,250 parts of water, and in 337 parts of alcohol; in 1,820 parts of boiling water, and in 34 parts of boiling alcohol; also soluble in 543 parts of ether, or in 2.4 parts of chloroform.

At 190° C. (374° F.) the crystals begin to agglutinate, and at about 209° C. (408.2° F.) they melt, forming a yellowish-brown liquid. When ignited, they are consumed without leaving a residue.

Elaterin is neutral to litmus paper.

Elaterin is dissolved by solutions of the alkalies, and reprecipitated on supersaturating with an acid.

When dissolved in cold, concentrated sulphuric acid, it causes the latter to become yellow at first, which color gradually changes to scarlet.

On dissolving some crystals of elaterin in melted carbolic acid, and then adding a few drops of strong sulphuric acid, a crimson color will be developed which soon becomes scarlet.

An alcoholic solution of elaterin should not be precipitated by tannic acid T.S., mercuric chloride T.S., or platinic chloride T.S. (absence of, and difference from, *alkaloids*).

ACTION AND USE.—Elaterin is the most active and certain of known hydragogue cathartics, purging repeatedly and comparatively painlessly in exceedingly minute doses. In larger ones, colic, nausea, vomiting, and prostration may follow. It is especially indicated when there is no inflammatory trouble in the digestive tract, and it is desirable both to empty the latter of its contents and to secure a copious transudation of water from the blood to its canal. Such conditions are frequently present in cardiac and renal diseases, accompanied by general dropsy; occasionally also in ascites from various causes, and in cerebral congestion, plethora, concussion, or compression of the brain, etc. For all these there is no better hydragogue than this. To be efficient, it should be given by the mouth, as it is very much less active in injections either into the rectum or into the cellular tissue; and in inunction it scarcely produces any but local effects. It is said, further, that the presence of bile in the intestines is essential to its full effect; but the proposition can scarcely be considered as finally settled. It is, no doubt, necessary that the intestinal contents should be alkaline.

Upon dogs, rabbits, and some other animals, it is an uncertain cathartic, and may even kill by nervous depression, without moving the bowels at all. After death by it, in man, signs of gastro-intestinal inflammation have been present.

ADMINISTRATION.—Elaterium is very variable in its strength, and while of Clutterbuck's or the best English the dose is about a centigram (gr. $\frac{1}{6}$ to $\frac{1}{8}$), that of the ordinary Malta or German varieties may be five or six times as large. In an untried sample, the smaller dose should always be started with and increased until found to be sufficient. ELATERIN is uniform, and should supersede the impure substance just mentioned. Dose 0.0015 to 0.006 (gr. $\frac{1}{40}$ to $\frac{1}{10}$). The officinal trituration (*Trituratio elaterini*, U. S. P.), strength $\frac{1}{10}$, is a convenient form. Dose, 0.015 to 0.06 gm. (gr. $\frac{1}{4}$ to 1).

Elaterin should always be given well diluted.

W. P. Bolles.

ELBOW.—*Extent.*—The term elbow is often used to indicate merely the angular projection made between the arm and forearm. The region of the elbow includes the joint and all the parts that surround and cover it. Externally there are no well-marked lines that separate this region from the arm above or the forearm below, and the rule established by Tillaux of limiting its boundaries to two finger-breadths above and two below the transverse cutaneous fold caused by the flexion of the joint, is probably as good as can be devised.

Configuration.—(See Fig. 1814.) In shape this region differs from those above and below, being somewhat broader, flatter, and hollowed in front by a shallow de-

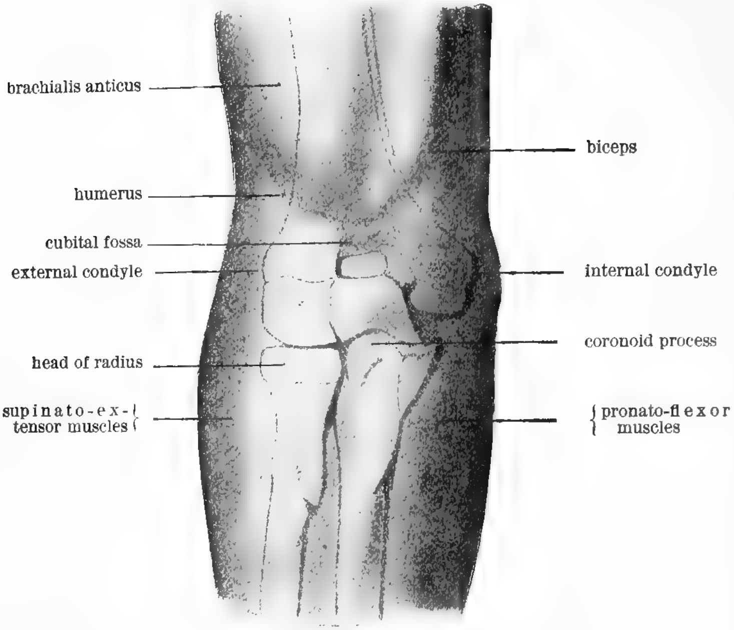


FIG. 1814.—The Elbow Viewed from the Front, the Bones Showing as if the Arm was Semitransparent.

pression known as the cubital fossa, distantly resembling the popliteal space behind the knee, while posteriorly a rounded projection appears even in the most extended state of the arm. These peculiarities of shape are due partly to skeletal form and partly to muscular grouping. On either side project the condyles of the humerus with muscular masses arising therefrom; behind, the olecranon process of the ulna forms the "point of the elbow" already mentioned. In front and behind, the muscles that have formed the rounded bulk of the upper arm become reduced to tendinous bands, thus occasioning the antero-posterior flattening.

The cubital fossa is shaped somewhat like a swallow's tail, hence the older anatomists called it the chelidon (χελιδών, a swallow). This shape is determined by the two converging muscular masses arising from the condyles on either side, between which is wedged the rapidly decreasing mass of the muscles descending from the front of the upper arm.

The bony landmarks about the elbow are of extreme importance in the diagnosis of injuries and as guides in surgical operations. At the outer side the external supracondylar ridge may be felt and readily traced downward to the external condyle. Below and behind this, between eminences caused by the supinator longus together with the radial extensors of the wrist on the outer side, and the anconeus internally, there is a depression, well marked in all individuals, at the bottom of which there may be felt the head of the radius.

At the inner side the internal condylar ridge may also be traced by pressing deeply. Occasionally there is found here, at a distance of one or two inches above the inner condyle, a bony hook known as the supracondyloid process. From the summit of this hook there extends to the condyle a fibrous band affording origin to part of the humeral head of the pronator radii teres muscle, and through the osteo-fibrous canal thus formed pass the brachial artery, or one of its branches, and the median nerve; the presence of this process is said to be associated with a high division of the brachial. This arrangement occurs in about one per cent. of individuals and appears to be the homologue of an osseous canal found in many mammals, such as carnivores, rodents, and some inferior apes.

The internal condyle is sharper, a little higher, and not so well covered with muscles as the outer one. It is therefore more prominent and must be carefully padded when splints are applied at the elbow. Its most prominent part is directed backward rather than inward. Between it and the olecranon is the groove by which the ulnar nerve passes to the lower arm.

The olecranon process projects more or less in all positions of the joint. Its upper border is obscured by the tendinous insertion of the triceps, which

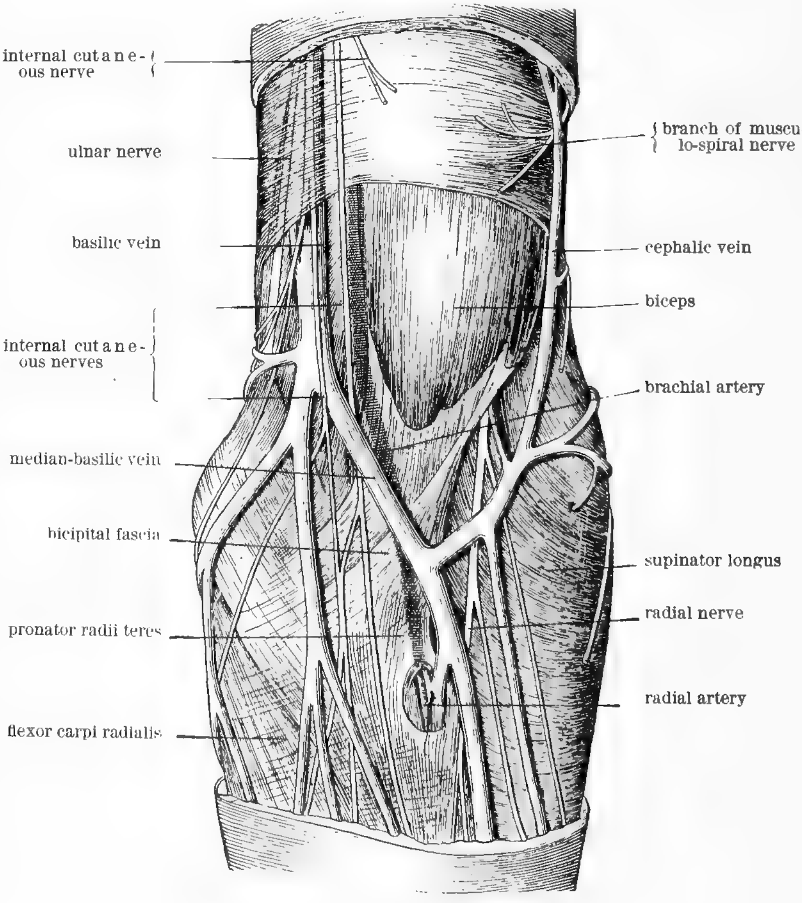


FIG. 1815.—Superficial Dissection of Region of Elbow.

usually has a bursa beneath it. A subcutaneous bursa is almost invariably found over that portion of its surface on which the weight rests when leaning on the elbow. The relative position of the upper border of the olecranon and the two condylar prominences varies according to the degree of flexion of the joint. When it is fully extended, the three prominences are in line; when at a right angle, the border of the olecranon is immediately beneath the condyles; in extreme flexion it is in front of them. These relations are important in judging of a dislocation, but unfortunately most cases are not seen until the swelling is so great that it is impossible to apply them accurately.

When the arm is strongly pronated, the tuberosity of the radius may usually be felt below the joint, in the interval between the radius and the ulna. The shaft of the ulna is much more easily felt than that of the radius.

The front of the joint is so well covered by muscles that but little aid can be obtained from bony landmarks. However, deep pressure at the bottom of the cubital fossa will, in lean individuals, reveal the tip of the coronoid process of the ulna.

Skin.—The skin in front of the elbow is especially thin, delicate, and transparent, the course of the subcutaneous veins being, in the white races, clearly visible through it. It is also readily movable. Because of these peculiarities care must be taken to avoid any considerable traction upon it when apparatus is used in this region, as it is easily excoriated and ruptured.

During flexion there appears in front a transient fold of skin which disappears on complete extension, differing in that respect from the folds of the fingers and palm. It lies some distance above the line of articulation and should not be used as a surgical guide.

Superficial Fascia, Vessels and Nerves (see Fig. 1815).—The subcutaneous fat or superficial fascia varies very much in different individuals. It may be sufficient to conceal the subcutaneous veins and be separable into two sheets between which the veins run. Embedded in it, just above the inner condyle, are a few lymphatic glands which receive the converging, superficial lymphatic trunks arising from a network about the lower arm and hand. These glands should be examined in case of suspected malignant growth in those regions.

The superficial veins at the elbow were formerly much used for the operation of blood-letting or venesection, and are still occasionally resorted to for that purpose. The reason for this choice is obvious. They are easily accessible and situated upon a portion of the body frequently exposed to view. They are also of sufficient size to make the operation effective, which is not usually the case with trunks more distally situated, and, with reasonable care, no untoward results need ensue. The anatomical relations should, however, be carefully studied. Their general course can be effectively shown in the living subject by binding a ligature just above the elbow sufficiently tight to retard the flow of blood in the superficial veins without arresting the current in the brachial artery.

According to the classical description, the superficial veins at the elbow consist of collateral anastomoses between three principal trunks which, running lengthwise up the forearm, are respectively known from their positions as the radial, ulnar, and median veins. Above the elbow the radial and ulnar pass immediately into the two great venous trunks of the upper arm: the cephalic, which runs up in the outer bicipital groove as far as the shoulder, and the basilic, which follows the inner bicipital groove about one-third the way up the arm, pierces the deep fascia at the hiatus semilunaris and joins the venæ comites of the brachial artery. The median vein, however, divides into two short, diverging trunks; one, the median-cephalic, passing to the cephalic trunk; the other, the median-basilic, passing to the basilic. These trunks are of larger calibre than the median, a circumstance that is explained when we find that somewhere near the point of their divergence a short anastomosing vessel, the deep median, perforates the deep fascia and brings them blood from the deep system of veins.

This arrangement is usually compared to a capital M, yet that imperfectly describes it, as the uprights must be extended both upward and downward and an additional member be added at the union of the diverging bars (see Fig. 1815).

The pattern thus sketched out is, however, by no means constantly followed (see Fig. 1816). The median vein is often replaced by a plexus; there may be two or more radial or ulnar veins that unite either above or below the elbow; frequently the radial vein forms the so-called median-cephalic and median-basilic, while an accessory radial constitutes the outer vertical bar of the M. In this case, the median vein, if there is one, discharges either into the radial before it divides or into the ulnar.

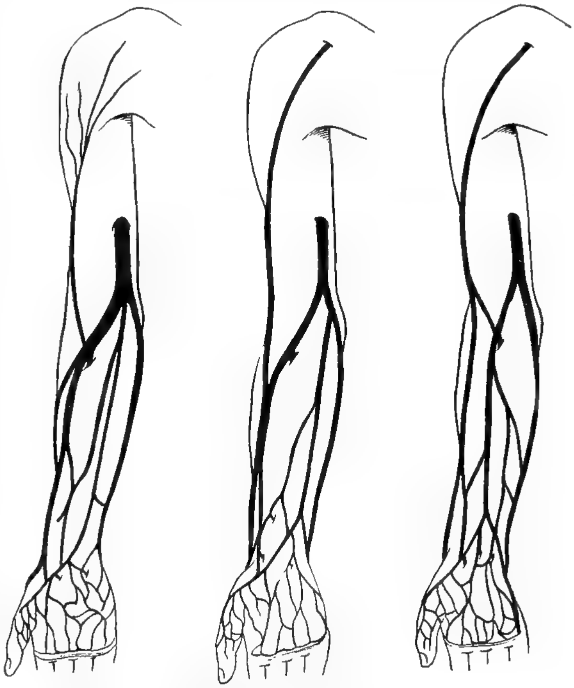


FIG. 1816.—Variation in the Veins of the Arm.

The median-basilic, usually larger, more superficial and more constant than the median-cephalic, runs almost parallel with the brachial artery just before its division, being separated from it by the fibrous expansion from the tendon of the biceps to the deep fascia of the lower arm (bicipital fascia, lacertus fibrosus). This gives it a somewhat firmer support when the arm is fully extended than can be afforded to the median cephalic, which is surrounded by yielding subcutaneous fat.

The vessels differ also in their relations to the cutaneous nerves that cross the cubital fossa to supply the lower arm. The internal cutaneous nerve breaks up, at some distance above the elbow, into several branches, the largest of which, piercing the deep fascia at the hiatus semilunaris, usually passes down in front of the basilic and median-basilic, sometimes forming a rich plexus along the latter vessel. On the radial side the cutaneous branches of the musculo-cutaneous nerve emerge from the deep fascia a little above or on a level with the external condyle. This is the most effective spot for its electrical excitation. It lies directly inward from the confluence of the median cephalic with the cephalic. Running along the median cephalic for a short distance, it divides into anterior and posterior branches, which supply corresponding surfaces of the forearm. Both of these usually descend behind the vessel, though occasionally the anterior branch passes in front.

The larger size and firmer bed of the median basilic make it easier to open, but its close proximity to the artery occasions accidents and the number of nervous filaments that must be cut to reach it is disadvantageous, as their section sometimes leads to painful neuritis. The median cephalic is therefore, on the whole, the safer vessel for venesection.

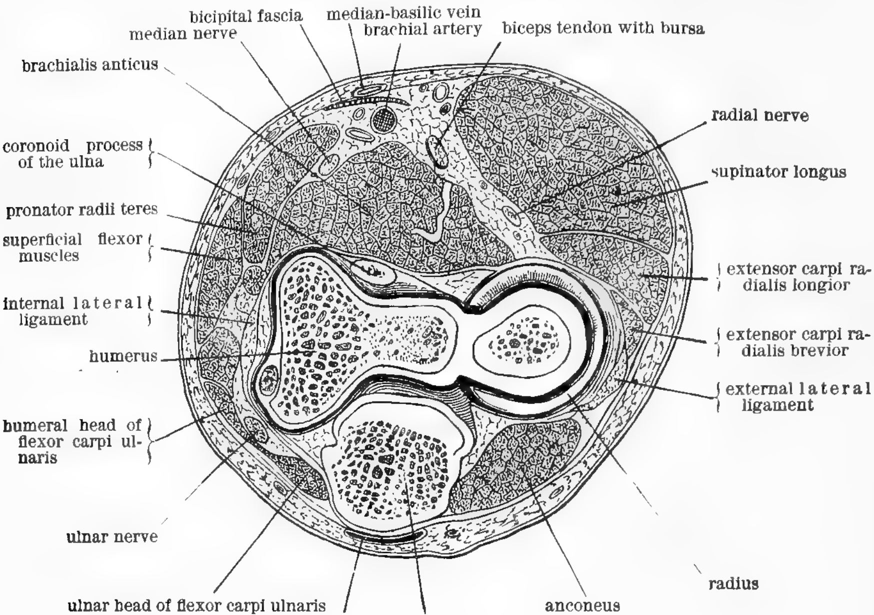

bicipital fascia
median-basilic vein
median nerve
brachial artery
biceps tendon with bursa
brachialis anticus
radial nerve
coronoid process of the ulna
supinator longus
pronator radii teres
superficial flexor muscles
extensor carpi radialis longior
internal lateral ligament
extensor carpi radialis brevior
humerus
external lateral ligament
humeral head of flexor carpi ulnaris
ulnar nerve
radius
ulnar head of flexor carpi ulnaris
bursa olecrani
olecranon
anconeus

FIG. 1817.—Horizontal Section through Elbow.

Deep Fascia.—(Fig. 1815.) This is continuous above with the deep fascia of the arm, below with that of the forearm. The intermuscular septa, so marked a feature of the fascia of the arm, are continued downward into the region of the elbow. The internal septum is the stronger, and lies between the brachialis anticus and the internal head of the triceps, attached to the supracondyloid ridge as far as the internal condyle. It is pierced by the musculo-spiral nerve. The external intermuscular septum is mainly represented in this region by the muscles attached to the external condyloid ridge, viz.: the supinator longus and the extensor carpi radialis longior, which lie between the brachialis anticus and the external head of the triceps.

At the elbow-joint the fascia becomes closely adherent to the muscles, to the condyles, and to the olecranon. It here receives several reinforcements, viz.: from the tendon of the biceps, the fibres passing over toward the inner condyle and the crest of the ulna; from the triceps, by expansions on either side of its tendon of insertion; an anterior fascicle from the internal condyle; a posterior fascicle from the external condyle; and fibres from the posterior border or crest of the ulna. From either condyle it sends down strong intermuscular septa between the muscles that arise therefrom, thus affording them additional areas of insertion. Except where reinforced it is thin, but somewhat thicker on the extensor surface of the arm. The general direction of the fibres of this fascia is circular, girdling the arm, but the fascicles of reinforcement are either longitudinal or oblique. At the point of the cubital fossa it is perforated by the deep median vein.

Muscles.—The muscles about the elbow are arranged somewhat like the links of a chain, the flexors and extensors of the lower arm lying on the anterior and posterior surfaces of the limb, while the pronators and supinators are at the sides. The mass coming down from the upper arm in front is composed of the biceps and the brachialis anticus (see Figs. 1817, 1818, 1819).

At the elbow the biceps develops from its fleshy portion a strong flat tendon that lies at first in the frontal plane, but as it descends into the cubital fossa, twists so that its outer border becomes anterior. Passing deeply between the radius and ulna it is inserted upon the posterior portion of the bicipital tuberosity. A bursa (*B. radio-bicipitalis*) constantly intervenes between the anterior portion of the tuberosity and the tendon, and not infrequently a second bursa (*B. ulno-radialis*) is found between its inner surface and the ulna, lying along the oblique ligament. It is because of the insertion of the tendon near to the posterior surface of the radius that the biceps is enabled powerfully to rotate that bone and thus supinate the hand. Owing to its preponderating influence, the force available for supination is much greater than that for pronation. This is turned to account in many tools and mechanical devices, such as gimlets and screws.

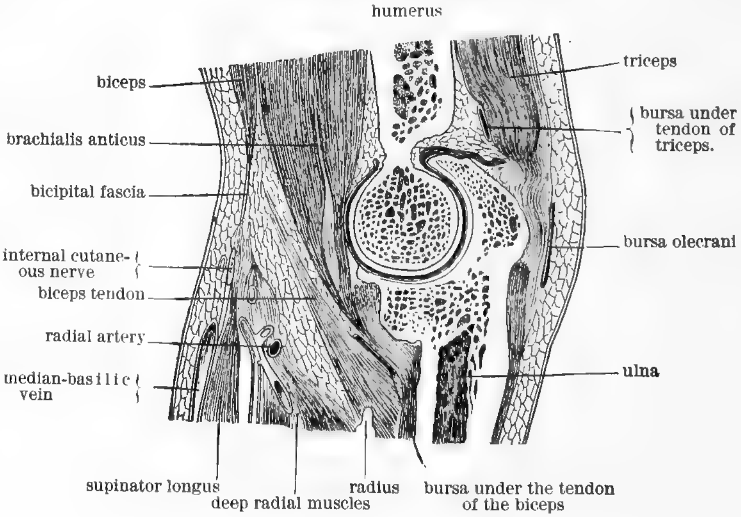


FIG. 1818.—Sagittal Section through Elbow.

Arising from the anterior surface and inner border of the main tendon of the biceps is the aponeurotic expan-

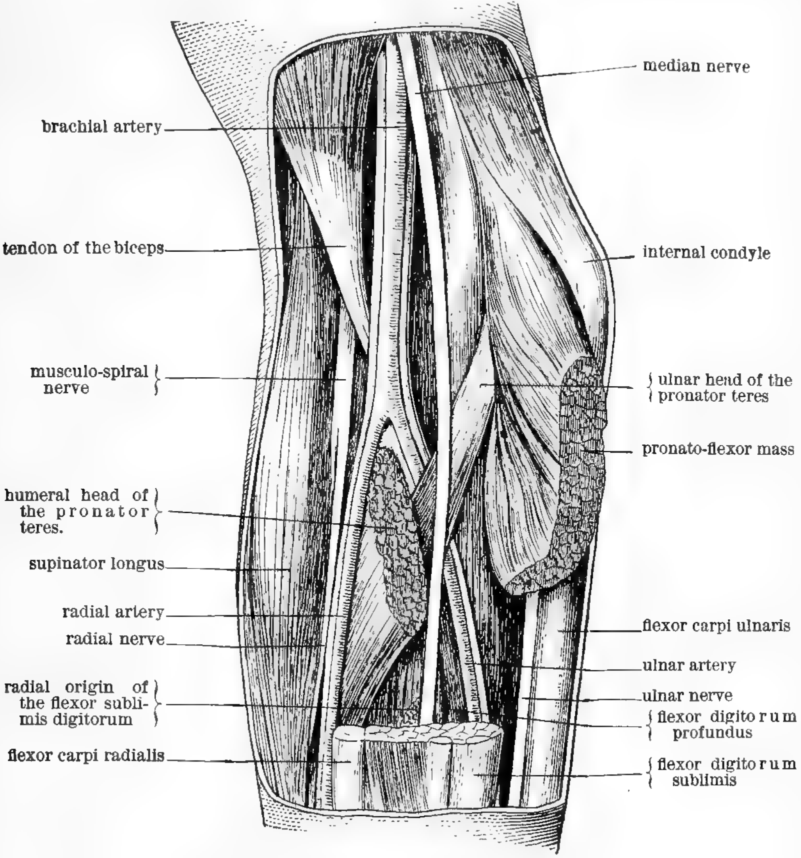


FIG. 1819.—Deep Dissection of the Front of the Elbow.

sion known as the bicipital fascia, also called the fascia semilunaris and the lacertus fibrosus, which is directed obliquely to the inner side of the forearm, its fibres reaching as far as the crest of the ulna. It has therefore been regarded as an ulnar tendon of the biceps. It passes over the brachial artery and the median nerve, separating them from the median basilic vein and the filaments of the internal cutaneous nerve.

The brachialis anticus lies beneath the biceps, directly in front of the elbow-joint. Thick and flat, it arises by direct implantation of muscular fibres from the lower portion of the humerus and the intermuscular septa, and is inserted by a broad, flat tendon upon the tubercle and the inferior surface of the coronoid process of the ulna. Being broader than the biceps, it becomes subcutaneous at the sides of the arm.

In close relation with these muscles there pass down into the cubital fossa the brachial artery with its accompanying veins and the median musculo-spiral nerves (see Figs. 1815, 1817, and 1819). The artery lies upon the brachialis anticus, against the inner side of the biceps muscle, almost exactly midway between the condyles. In this situation the position of the artery is clearly indicated by the broad, glistening white tendon of the biceps on its outer side and the smaller, rounder, and more yellowish cord of the median nerve that runs parallel to its inner border. It usually divides into its terminal branches, the radial and ulnar arteries, just below where the bicipital fascia stretches over it, viz., about a finger's breadth below the bend of the elbow, opposite the junction between the head and the neck of the radius. It is associated with two companion veins that intercommunicate by numerous transverse branches, increasing somewhat the difficulty of isolating the artery for ligation. Its depth and confined position make it possible to compress it by forced flexion of the joint, and hemorrhage from the radial or ulnar arteries may be thus controlled. The bicipital fascia acts as a reinforcement of its outer coat, and this is thought to be one reason why aneurism is much less frequent here than in the popliteal space of the lower limb. It should be noted that the thickness of the bicipital fascia varies much in different individuals, being not infrequently so thin and indistinct that it might be mistaken for ordinary connective tissue.

Collateral branches from the large vessels mentioned above form about the elbow a network (*rete olecrani*) of arterioles important for the nourishment of the region (see Fig. 1820). For this reason tight bandaging is likely to interfere with healing processes in the neighborhood of the elbow. The branches that form this network are, from above, the superior and inferior profunda and the anastomotica magna, derived from the brachial; from below, the radial recurrent, the interosseous recurrent and the anterior and posterior ulnar recurrents. About the external condyle branches from the superior profunda descend, anastomosing with the radial recurrent in front and the interosseous recurrent behind; about the internal condyle the inferior profunda and the

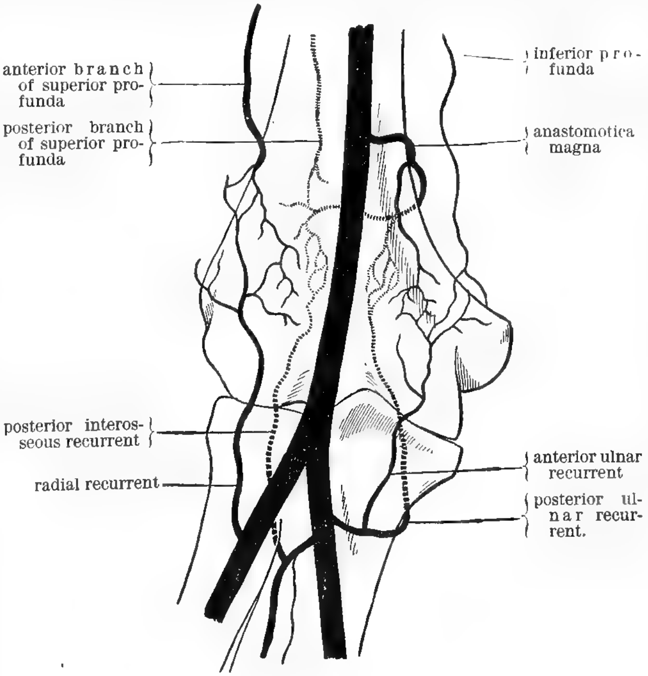

anterior branch of superior profunda
inferior profunda
posterior branch of superior profunda
anastomotica magna
posterior interosseous recurrent
anterior ulnar recurrent
radial recurrent
posterior ulnar recurrent.

FIG. 1820.—Anastomosis of Arterial Branches about the Elbow.

anastomotica magna descend, uniting with the anterior and posterior ulnar recurrents. The anastomotica magna also sends an arch across above the olecranon, uniting with all the other vessels on the posterior surface of the elbow.

The median nerve, having crossed the brachial artery above at a very acute angle, lies in this region at its inner side, usually separated from it by a slight interval. It then passes deeply between the two heads of the pronator radii teres, the coronoid head separating it from the division of the brachial and the ulnar artery, and finally leaves the region of the elbow and gains the middle of the forearm by passing under the arch of the flexor sublimis digitorum. The motor branches of the median nerve are all given off at or near the elbow. Sometimes all the branches for the forearm are derived from a common trunk which then might be known as the deep median nerve (*N. profundus medianus*, Schwalbe). The usual arrangement, however, is for three nerves to separate in succession: (1st) one that supplies the humeral head of the pronator radii teres, given off a little before the nerve passes under the bicipital fascia; (2d) a trunk for the superficial muscles of the forearm, given off between the two heads of the pronator radii teres and including a branch for the coronoid head of that muscle; (3d) a trunk for the deep muscles of the forearm, usually given off between the pronator radii teres and the flexor sublimis digitorum.

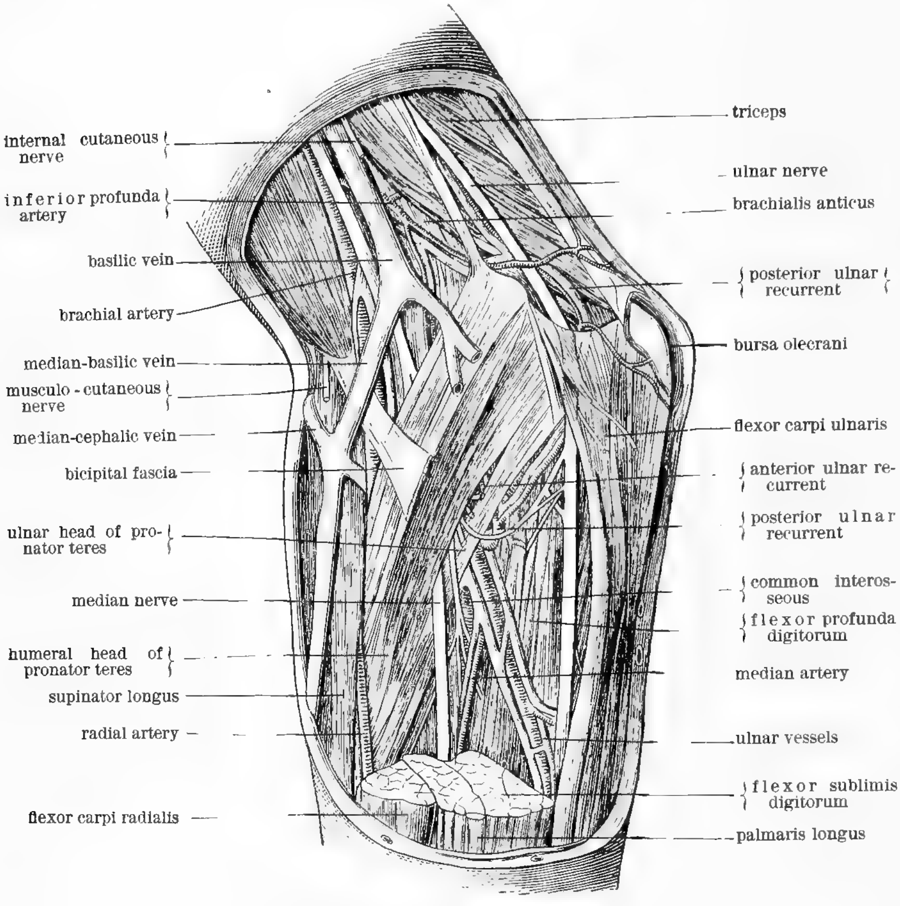


FIG. 1821.—Dissection of the Elbow from the Inner Side.

The musculo-spiral nerve, after winding around the humerus from behind, reaches the region in front of the elbow a short distance above the condyles, by perforating the external intermuscular septum. It then lies at the bottom of the external bicipital groove, against the fibres of the brachialis anticus which separate it from the joint capsule, and between the supinator longus and the biceps. It divides, usually at the level of the articulation or slightly above it, but sometimes as far down as the head of the radius, into the posterior interosseous and radial nerves. The radial recurrent artery often lies in the angle of bifurcation. The posterior interosseous branch, exclusively motor, leaves this region by perforating the supinator brevis muscle and thus reaching the back of the forearm. The radial proceeds downward under cover of the supinator longus, lying to the outer side of the radial artery.

Behind the elbow the muscular mass is composed of the triceps and the anconeus, its continuation upon the lower arm. The portion of the triceps that comes properly within this region is its insertion, which consists, first, of a thick, firm, aponeurotic expansion which receives fibres from all the heads and is inserted upon the superior surface and lateral edges of the olecranon; second, of fibres from the external and internal heads that are implanted without any intermediary tendon directly upon the olecranon.

Below and externally the triceps blends intimately with the anconeus, there often being no appreciable interstice between them. This continuity and its supply by the same branch of the musculo-spiral nerve that innervates the internal head of the triceps, have led some to the conclusion that the anconeus should be considered as a fourth head of the triceps. It radiates fan-like from a short and strong tendon attached to the posterior and inferior portion of the external condyle, its fleshy fibres being inserted by direct implantation into the side of the olecranon and over the entire extent of the excavated posterior surface of the ulna that lies above the oblique line.

At the sides of the elbow the muscular masses are arranged in two groups, quite distinct in their origin, function, and innervation. The inner group arises from the internal condyle or near it, contains pronators and flexors, and is innervated by the median and ulnar nerves; the outer group arises from the external condyle and the condylar ridge above it, contains supinators and extensors, and is innervated by branches from the musculo-spiral nerve.

Some explanation of the peculiarities of these lateral muscles is afforded by the history of the development of the arm. In the fœtus each limb arises as a budlike outgrowth from the trunk, and is covered by a prolongation of the ventro-lateral common muscular sheet. As it increases in length this prolongation becomes segmented near the elbow into a pronato-flexor mass and a supinato-extensor mass. In lower animals, like reptiles, that have no independent movements of the different parts of the hand, these masses remain in their primitive condition, but in those that have a variety of movements for the hand, the masses become split into layers and finally into distinct muscles. Irregularities in this process cause numerous varieties. In adult man traces of the primitive condition persist at the place of origin of the muscles, many of which continue to spring from an undifferentiated mass, or, as it is styled, from a common tendon.

The muscles of the pronato-flexor mass found in the region we are considering are the pronator radii teres, the flexor carpi radialis, the palmaris longus, the flexor carpi ulnaris, and the flexor sublimis digitorum. The first four of these form a superficial layer, while the flexor sublimis constitutes a layer by itself (see Fig. 1821).

The pronator teres lies farthest to the radial side and therefore forms the inner boundary of the cubital fossa. Besides its origin from the internal condyle it has a slip attached to the coronoid process of the ulna. Between these two slips of origin passes the median nerve as already mentioned.

The flexor carpi radialis and the palmaris longus have no special anatomical importance in this region, merely arising from the internal condyle by the common tendon and presenting spindle-shaped masses lying approximately parallel to the pronator. The flexor carpi ulnaris arises by two heads, one from the internal condyle by the common tendon, one from the olecranon and the upper two-thirds of the crest of the ulna. These heads are united by a fibrous arcade under which pass the ulnar nerve and the posterior ulnar recurrent artery. The nerve descends behind the internal muscular septum, accompanied by the inferior profunda artery which lies in front of it, enters the slight groove behind the internal condyle, sometimes held in place by a slight elevation of bone arising from the condyle. It is here in close relation with the internal lateral ligament of the elbow-joint, which throws over it a fibrous investment which, according to Sutton, is the remains of an atrophied muscle, the epitrochleo-anconeus, rarely found in man but common in apes. These fibres help to fix the nerve and prevent it from slipping from its groove, a common accident in dislocations. During flexion the groove widens somewhat owing to the slight lateral displacement of the humerus. A small bursa often lies between the nerve and the bone, necessitated by the movements of the nerve during flexion and extension. In this situation the nerve is almost subcutaneous, crossed by branches from the internal cutaneous nerve, and as it lies against an unyielding surface it is particularly subject to injury when the inner edge of the elbow is struck. This has led to the designation of its locality as the "funny bone." It is mainly on account of the presence of the nerve on this side that the joint is opened from without in operations for resection.

The flexor sublimis digitorum has also a double origin, one by a thick and strong slip from the internal condyle and coronoid process by the common tendon, closely blended with the internal lateral ligament of the joint, another by a broad and thin lamina from the oblique line and anterior border of the radius. The two heads united bound an oval foramen through which pass the median nerve and the ulnar artery.

The muscles of the supinato-extensor mass found in this region are divided into two groups: an external one, comprising the supinator longus and brevis and the two radial extensors of the wrist; and a posterior one, comprising the common extensor of the fingers, the extensor of the little finger, and the ulnar extensor of the wrist. The ulnar crest separates these groups from the pronato-flexor muscles.

The supinator longus is the most superficial of its group, arising from the upper two-thirds of the external supracondyloid ridge of the humerus and from the external intermuscular septum, and extending down along the outer side of the forearm to which it imparts its characteristic shape. The muscle is drawn forward by the deep fascia of the forearm and forms the external boundary of the cubital fossa. Above the elbow it lies upon the musculo-spiral nerve and the radial recurrent artery, below upon the radial vessels and nerve. Its functions as a supinator are brought into play only when the arm has been previously strongly pronated. Its usual office is that of a flexor of the forearm.

Closely connected with the supinator longus at its origin is the long radial extensor of the wrist, for its fibres immediately succeed those of the supinator upon the external condyloid ridge, here somewhat enlarged, extending down for about an inch, or to the base of the condyle. It is partly covered by the supinator longus and is in contact with the upper part of the capsule of the joint.

Lying directly under the foregoing and arising from the anterior surface of the external condyle is the short radial extensor of the wrist. The two muscles are not infrequently interblended in various ways.

The supinator brevis lies deeply under both of these, a bursa usually intervening, and close against the joint capsule. Arising from the lower part of the external condyle and the common tendon, also from the interosseous border of the ulna and the excavation below the lesser sigmoid cavity, its fibres run spirally from above downward and outward and are inserted around the upper third of the radius, embracing the neck and reaching the tuberosity and the oblique line. It adheres closely to the external lateral and orbicular ligaments of the elbow-joint. The muscle is divided into two planes of fibres between which the posterior interosseous nerve passes. It shares with the biceps the function of supinating the hand and arm by rotating the radius.

The muscles of the posterior region of the upper forearm radiate from the external condyle just below the anconeus. The common extensor of the fingers is the most external of these, appearing in this region as an undivided pyramidal mass arising from the lower and anterior portion of the condyle and the common tendon. It is in contact with the external lateral ligament and the supinator brevis and wedged between the short radial extensor and the ulnar extensor.

Interposed between the common and ulnar extensors and seemingly differentiated from the former is the extensor of the little finger. It arises mainly from the fascia of the forearm and the septa that lie between it and the two contiguous muscles. In about four per cent. of cases its muscular belly is indistinguishable from that of the common extensor.

The ulnar extensor of the wrist runs diagonally across the back of the arm from the external condyle to the ulnar side. It arises from the lower and posterior portion of the condyle and the common tendon, from a strong intermuscular septum that springs from the upper three-fourths of the crest of the ulna and from the fascia of the forearm. A bursa is often found beneath its condylar tendon, often extending also beneath the origin of the common extensor.

Elbow-joint.—In this important joint there are united in a single capsule three articulations: one between the humerus and the ulna; one between the humerus and the radius, and one between the ulna and the radius. This diversity of union permits a great variety of motions for the forearm and hand and determines largely the distinction that exists between the upper and the lower extremity. Thus there is produced by this means an angular motion of great steadiness by which the forearm is flexed and extended, and also a motion by which the radius and ulna are altered in their relations, being made to turn over each other across their long axes, and thus rotate the attached hand. Movement of this kind toward the median line, turning the palm downward, is termed pronation; in the opposite direction, turning the palm upward, supination.

The humero-ulnar articulation gives the whole system solidity, its strength being due to the configuration of the articulating surfaces, and the peculiar arrangement of the ligaments.

The humerus presents at its lower end a surface curved like an Ionic volute, and grooved like a pulley, which gives it its name of trochlea (see Fig. 1822). The surface is obliquely directed, and the groove is not quite symmetrical, but has a slight lateral twist. On this surface the ulna glides, embracing it by the gap between the olecranon and the coronoid processes known as the greater sigmoid cavity (see Fig. 1823), not quite a semicircumference, the olecranon passing up behind into the fossa of that name in the humerus when the arm is extended, and the coronoid process similarly fitting into its appropriate fossa in front during flexion (see Fig. 1824). The coronoid and olecranon portions of the ulnar surface are separated by a transverse line devoid of cartilage (see Fig. 1823), corresponding to the place where the epiphysis unites with the shaft. The whole olecranon process is a secondary growth, as in fœtal life the joint begins its development as a simple slit between two ends of bone which are apposed very much as the ends of the finger bones are in the adult. At birth the process is not completely developed, and the olecranon and coronoid fossæ of the humerus are not so deep as they are in the adult. It is interesting to note that in renewal after resection the fœtal conditions reappear, the ulna not usually acquiring an olecranon, but resembling more the upper end of the tibia. The transverse line above mentioned is crossed at nearly right angles by a guide ridge which fits into the deepest part of the trochlear groove. The direction of this is not quite the same in the two portions, and a piece cut from the olecranon or coronoid process will not exactly fit all parts of the trochlea. There is usually, therefore, a slight deviation or lateral wabbling of the joint in flexion and extension, which is not, however, sufficient to be noticeable without instrumental measurements. The results of tracings made by points carrying ink are shown in Figs. 1825 and 1826, the two lines there drawn on the trochlea being tracings of points attached to the coronoid and olecranon processes, respectively. The curves bend and return into each other, so that, though there is a slight lateral working, it is readjusted before the end of the course. This may be easily demonstrated by observing, during flexion and extension, a spot of ink placed on the most prominent point of the olecranon. By carefully sighting this with a vertical thread, it will be seen to move laterally. It may also be demonstrated by making a vertical section through the extended joint, and then flexing, when the cut surfaces of the bones will be seen to ride past each other. It appears, then, that there is a slight interval between the articular surfaces at the sides, only the guide ridge remaining constantly in contact. The joint cannot, therefore, be said to be a perfect hinge, although it may be so regarded for all practical purposes.

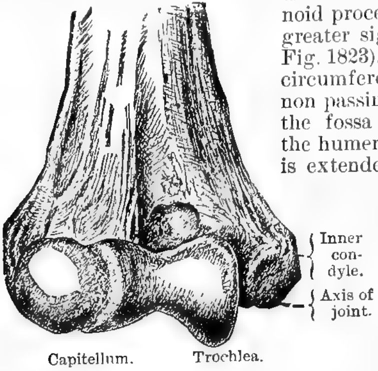


FIG. 1822.—The Lower End of the Humerus, showing the Articular Surface.

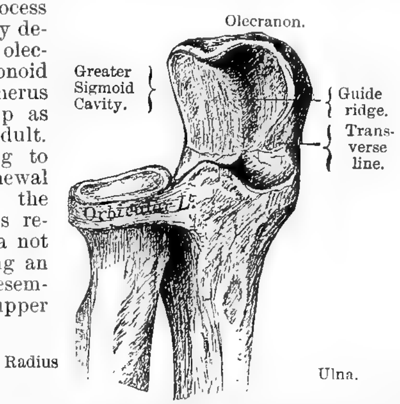


FIG. 1823.—The Upper End of the Radius and the Ulna, showing the Articular Surfaces.

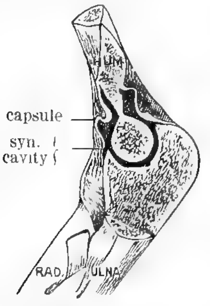


FIG. 1824.—A Sagittal Section through the Elbow-joint, showing the Adaptation of the Articular Surfaces, and Folds of the Capsular Ligament.

External to the trochlear surface of the humerus, and separated from it by a shallow groove, is a rounded portion about as large as an ordinary marble, called the capitellum or radial head (see Fig. 1822). It does not extend far back, but looks directly forward, and the button-like head of the radius which articulates with it can be felt behind, moving from side to side when the extended arm is supinated. This is an important assistance in diagnosticating dislocations and other injuries here. The head of the radius is in contact with the capitellum only when the forearm is flexed at right angles; during complete extension its anterior edge touches but its posterior half is entirely free. The shallowness of the depression by which the radius fits would make the joint very insecure, were it not that that bone is bound sidewise to the ulna by a strong band called the orbicular ligament (see Fig. 1823), articulating in a shallow depression called the lesser sigmoid cavity. The broadest part of the radial rim fits this, in the position of the arm which is most usual, viz., that of semi-pronation. The rim passes a little beyond the sigmoid cavity and just touches the bevelled edge which separates the capitellum from the trochlear portion of the humerus, rolling upon it in pronation and supination. The combination of flexion with pronation, and of extension with supination, are therefore in accordance with the nature of the articular surfaces. The line of the articulation is oblique, and in amputating it is useful to remember that it lies about three-eighths of an inch below the external condyle, and one-fourth inch lower on the inner side. The head of the radius, which can be felt as mentioned above, is the best guide to it.

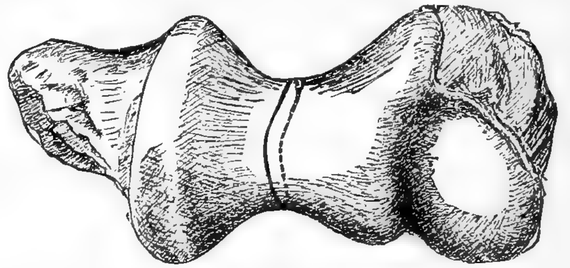


FIG. 1825.—The Trochlear Surface of the Humerus, showing Tracings of the Paths of the Olecranon and Coronoid Processes of the Ulna during Flexion and Extension. (After Braune and Kyrklund.)

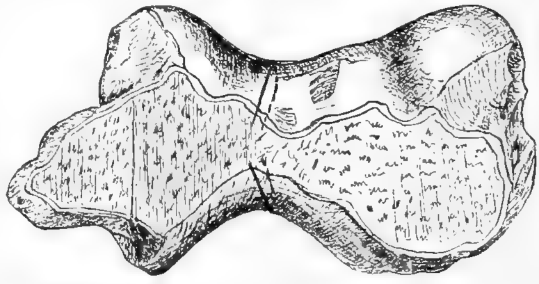


FIG. 1826. The Same Detached from the Shaft, so as to show how the Paths meet if continued.

From the configuration of the surfaces here described, it will be noticed that lateral luxations must be rare, the dislocation outward being easier than inward; that antero-posterior luxations are easier and can be effected in any position of the joint, the posterior one being necessarily the most common. When a single bone is dislocated it must be the radius.

A fibrous capsular ligament lined with synovial membrane invests the joint. Above and below it is attached beyond the articular surfaces of the corresponding bones, the head of the radius being, as it were, stuck through a slit in it. Being quite loose, to admit of extensive movements (see Fig. 1824), it would be nipped in front and behind during flexion and extension, were it not held out of the way by the flexor and extensor muscles which blend intimately with it. It is further protected by a pad of fat in each fossa, and over this the muscles pull. The capsule is thinner behind than in front, and an effusion into the joint cavity first shows there, on either side of the olecranon and the tendon of the triceps.

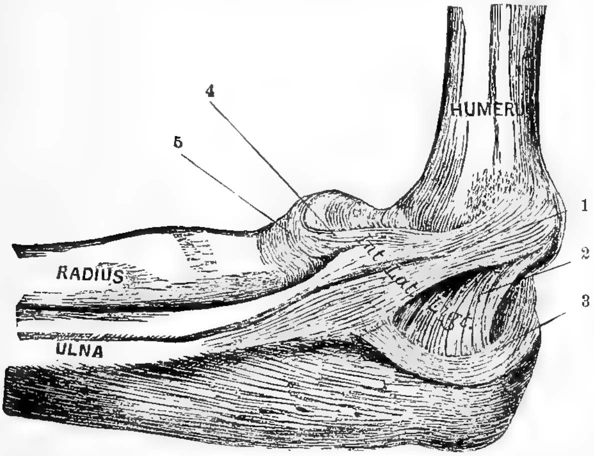


FIG. 1827.—View of the Ligaments of the Elbow-joint from the Inner Side. 1, Band extending from the condyle to the tuberosity of the coronoid process; 2, radiating bundles from the condyle to the border of the greater sigmoid cavity; 3, arciform fibres which pass forward from behind and protect the ulnar nerve; 4, oblique band which passes to the head of the radius, blending with 5, the orbicular ligament of the radius.

In certain situations the capsule is strengthened by accessory bands, which have received special names. The strongest of these are the lateral ligaments, which radiate from points on the humerus which are approximately in a line with the axis of rotation, and some of their fibres are therefore tense in every position of the joint. They are important sustainers of the articulation—indeed, if they are intact the anterior and posterior portions of the capsule may be removed without affecting the security of the joint. They also prevent the coronoid and olecranon processes from quite reaching the bottom of their respective fossæ in the humerus, which might cause chipping of the bone.

The internal lateral ligament (Fig. 1827) presents several small bundles, which radiate to the coronoid process and the internal border of the olecranon. In front it is intimately blended with the origin of the flexor sublimis digitorum; behind it forms, together with some arching fibres and the tendon of origin of the flexor carpi ulnaris, a smooth groove for the ulnar nerve, which lies so closely on the ligament that it cannot be divided here without risk of opening the joint. In forced extension, caused by violence, the internal lateral ligament is always ruptured or injured, and the bones are fractured in some manner. The anterior band of the ligament appears to check pronation, as it is ruptured when this movement is violently performed. In forced flexion the posterior band is frequently torn. In fracture of the olecranon this ligament often prevents separation of the fragments.

The external lateral ligament (Fig. 1828) blends in front with the supinator brevis, the tendon of origin of that muscle being, in fact, a part of it. Below, it unites with the orbicular ligament, sends a strong band to a tubercle below the lower sigmoid cavity of the ulna, and adheres to the internal edge of the olecranon. In forced movements (except adduction) this ligament does not usually give way until others are ruptured. The middle band is especially strong, and may tear a piece off the bone before parting. If the orbicular ligament is broken, the supinator brevis and the biceps pull the radius out of its socket. As this bone is more loosely attached than the ulna, the accident is not infrequent, being usually caused by falls on the pronated hand, or, in young children, by a strong jerk on the arm.

The orbicular ligament is considerably more elastic in children. A band, sometimes described as the quadrate ligament, usually passes from the lower border of the sigmoid cavity to unite with the orbicular ligament (Fig. 1828). Ordinarily relaxed, it limits pronation and supination.

The synovial membrane is large, and contains numerous deposits of fat, which are especially abundant in front and behind.

Flexion and extension may, as stated above, be considered for practical purposes as occurring in a single plane. The plane of flexion and extension is not parallel with the median plane of the body, but is directed obliquely, so as to carry the hand toward the mouth. This results from the fact that the axis of rotation of the joint is not at right angles to the long axis of the humerus, but makes with it an angle of some twenty degrees (see Figs. 1828 and 1830). This obliquity does not occur in the fœtal joint, and is marked in the lower races of men or in the anthropoid apes. In them ease of bringing the arm across the body is effected by an obliquity of the trochlear axis to the frontal plane. This can be measured by noting the inclination of the trochlear axis to a line drawn through the axis of motion in the head of the humerus. Careful measurements made by Welcker, Lucæ, Gegenbaur, and Schmid show that this angle averages about sixteen degrees in Europeans and thirty-two degrees in negroes and Malays (see Fig. 1829).

In the fœtus the angle is about forty-three degrees, and in a child of one year about thirty-eight degrees. It would appear from this that the humerus has undergone a twisting about its long axis to bring the palmar surface of the hand forward, and thus make it more useful as a prehensile and tool-using organ, and that this is more complete in the higher races. When this torsion becomes nearly complete it would make it difficult to carry the

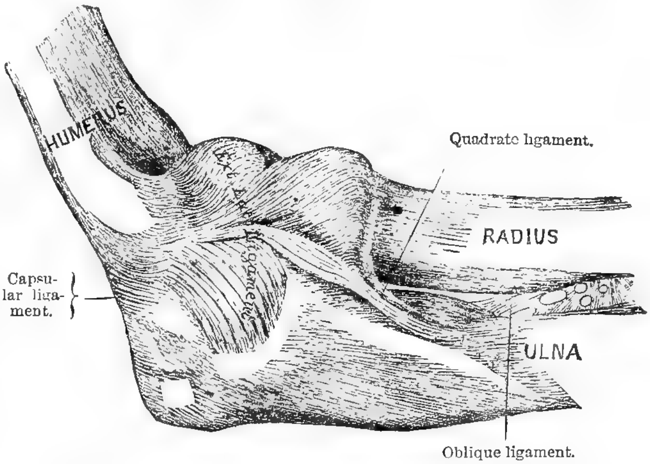
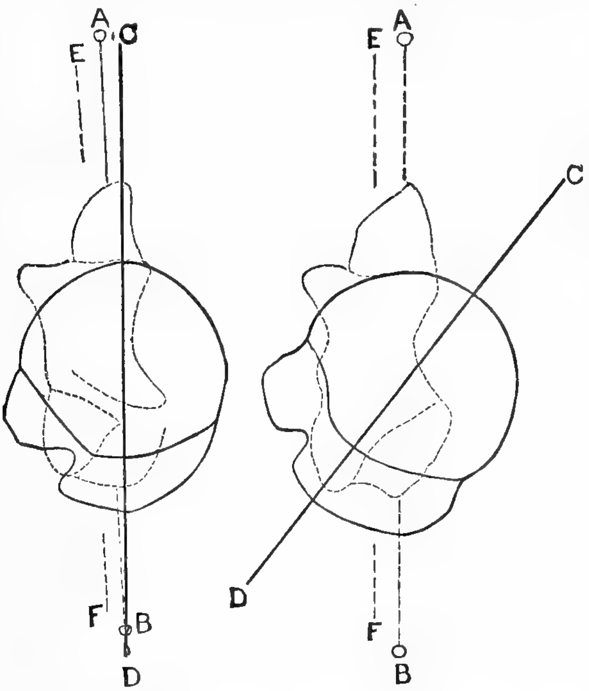


FIG. 1828.—View of the Ligaments of the Elbow-joint from the Outer Side.

hand across the body, were it not compensated for by the inclination of the trochlear axis which proceds *pari passu* with it.

As a result of this inclination the arm and forearm make, in extreme extension, an outwardly directed angle of about one hundred and sixty-five degrees. This is most marked in supination, and almost entirely disappears on pronating the hand. It is therefore best, when applying extension to the humerus by pulling the hand, first to effect pronation. When the muscles are relaxed the force of gravity necessarily carries the hand into a semi-prone position with the thumb to the front. The attitude of "attention" prescribed by tactics for a soldier, *i.e.*, with the palm forward, is therefore a forced one.



EUROPEAN. AFRICAN.

FIG. 1829.—Inclination of Axis of Elbow-joint to the Frontal Plane of the Body. *A*, *B*, Line drawn through the condyles of the humerus; *C*, *D*, line drawn through the long axis of the articular surface of the head of the humerus; *E*, *F*, axis of elbow-joint. (After Welcker and Lucæ.)

When a body like a ball is grasped by the hand and thrown by suddenly extending the arm, the inclination of the axis of the forearm causes it to be sent obliquely unless this is counteracted by strongly pronating the forearm. This pronation is the so-called "twist" of baseball pitchers. In performing it the limb is slightly lengthened. This may be demonstrated by standing so as just to touch a horizontal table with the end of the index finger in pronation and then supinating the hand, when the finger will be found to rise about three-eighths of an inch. The mechanism of this will be apparent on inspecting Fig. 1830, which shows that the plane *f*, in which the lower end of the radius moves, is oblique to the plane of the table.

Pronation and supination involve not only the movements of the bones in the superior radio-ulnar articulation, but also the movements of the radius and ulna at the wrist. Anatomists have been divided in opinion as to exactly what part is taken by each bone in this motion. By far the greater number have held, with Galen, Vesalius, and Albinus, that the ulna can take no part in the movement, being incapable of lateral motion at the elbow. The prevailing view is illustrated in Fig. 1831, which represents the usual method of articulating the bones for class demonstration. A fixed axis passes through the head of the radius above and the head of the ulna below, so that the radius flaps back and forth around this in a way that may be rudely expressed by two boards obliquely hinged together (Fig. 1832).

It is rather strange that the absurdity of this view has not been more generally seen, especially as a movement of the ulna was recognized by Winslow, Monro, and Vicq d'Azyr, the latter anatomist demonstrating it by the impression which the rotating hand left in a bed of clay.

Cruveilhier (following Bertin) declared this movement to be only apparent, and that by stripping off the muscles from the shoulder down and fixing the humerus, the immobility of the ulna could be demonstrated. The general treatises on anatomy have copied this statement with great docility, only a few investigators insisting, notwithstanding the weight of authority, that the ulna actually does move. Among these is Duchenne, who, by observing the movements of the end of a style fixed transversely upon the ulnar prominence of his own wrist, declared that the lower extremities of the radius and the ulna describe semicircles equal in extent and opposite in direction. Lecomte showed that by fitting an inextensible ring around the wrist above the styloid processes the movements of pronation and supination could still take place, which would not be the case were the radius alone active. He believed the ulna to be capable of circumduction, and pointed to the multiple facets in the sigmoid cavity as being proof that there is a riding from side to side. He compared the bones of the forearm to two revolving axles (arbres) parallel, supporting and pivoting upon each other with their extremities united by very movable articulations. The ulna has a pronator, the anconeus, and a supinator, the pronator quadratus. This latter muscle shows, by its attachment wrapping around the shaft of the ulna, that it is intended to roll that bone toward the radius.

Later observers have pointed out that, as Lecomte discarded all experiments on the cadaver, he could not have been sure that he fixed the humerus, and that consequently many of his results arise from the slight rotation of the humerus which usually accompanies pronation and supination. The ring causes forced and unnatural movements. A mathematical calculation shows that the action of the pronator quadratus must vary according to the situation of the axis around which the bones turn, and may be in one direction or the other, as that axis varies.

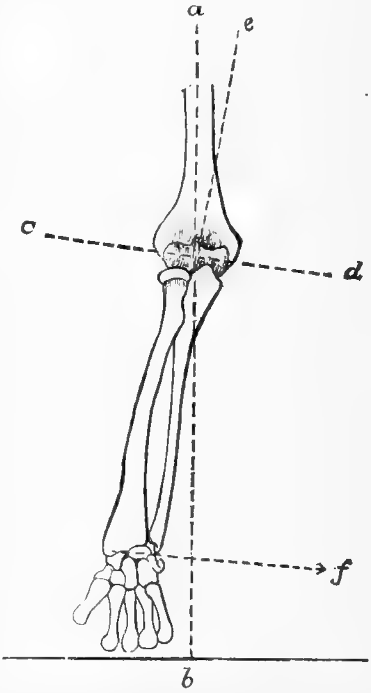


FIG. 1830.—The Bones of the Right Arm in Extension and Supination. *a*, *b*, Axis of humerus; *c*, *d*, axis of motion of elbow-joint; *f*, the plane in which the styloid process of the radius moves in pronation and supination.

In 1883 Heiberg published the results of some investigations made by him on the cadaver, which seemed completely to confirm Lecomte's views. Disarticulating at the wrist, he inserted into the radius and the ulna stiff rods, at the end of which were brushes charged with ink. It was necessary to use brushes, as the motions described were not in a single plane. On effecting movements of pronation and supination, these brushes described on paper curves which are approximately shown in Fig. 1833.

That for the radius is rather flat and appears to be a portion of a cycloid, while that for the ulna is smaller and is nearly an arc of a circle. In order to ascertain if similar results could be obtained in the living subject, he strapped a metal rod firmly to the arm along the edge of the ulna, carrying it out beyond the olecranon process so far that the distance between the lower edge of the greater sigmoid cavity and the end of the rod should be approximately equal to the distance between the same point and the styloid process of the ulna.

This upper end he found to describe curves which were similar to those described by the lower end in the cadaver, and he therefore concluded that the ulna describes movements of circumduction during pronation and supination, the lower portion generating a conical surface and the upper portion another, the vertices of the cones meeting at the lower edge of the greater sigmoid cavity. He presented his views to the International Medical Congress in 1884, and a lively discussion ensued. It was pointed out that his apparatus must necessarily produce very inexact results. Since that Cathcart has stated that in patients who have ankylosis of the humerus at the shoulder-joint he finds pronation and supination to be difficult, and Flesch found that in an apparatus rigged to imitate the elbow-joint the movements of the ulna appeared to be mainly those of flexion and extension. In the living subject the anconeus strongly contracts during pronation, and the brachialis anticus and flexor carpi ulnaris during supination.

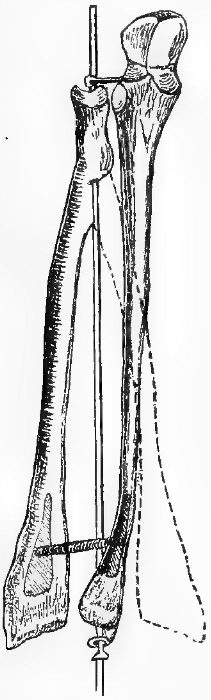


FIG. 1831.—Usual Method of Illustrating the Movements of Pronation and Supination. The radius and ulna joined together by means of a rod passing through the head of the radius and the head of the ulna.

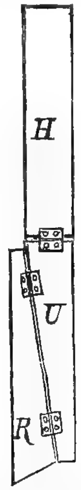


FIG. 1832.—The Same Mechanism Illustrated by Pieces of Board Hinged Together. (After Welcker.)

My own experiments completely confirm this. The most important paper that has recently appeared has been one by Braune and Fischer, who made, during 1885, a series of most careful experiments on the cadaver, in order to establish the character of Heiberg's curves of movement. The cadaver used was that of a suicide, and quite recent. The motions were induced by weights and pulleys acting as nearly as possible in the line in which the muscles pull during life, and pains were taken not to force them by making the weights too heavy. Styles were inserted firmly into the ulna and radius, and the path described by their ends was carefully observed and traced upon glass in at least two planes, or marked by reflecting mirrors on a wall. From the tracings, a system of co-ordinates was obtained by which the path of each style was calculated. It was found that the paths described by the ulna belonged to no regular curve, but were a series of motions of flexion and extension, with a slight degree of lateral motion.

These results agree with experiments which I have myself made on this subject, but it should be added that the amount of ulnar movement undoubtedly varies considerably according to circumstances, and that the axis of motion, instead of being fixed, as usually stated, changes according to the act performed.

Frank Baker.

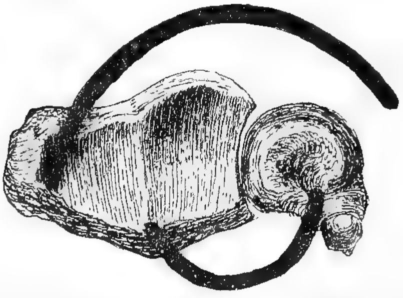


FIG. 1833.—The Lower Ends of the Radius and Ulna; showing the Movements of Pronation and Supination. (According to Heiberg.)

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ELECAMPANE.—Inula. The root of *Inula Helenium* L. (fam. *Compositæ*).

This is a large, rank, perennial herb, with a thick fleshy rootstock and root, and an upright, branched, hairy or rough stem, from one to two yards high. The lower leaves are half a yard or more long and half as broad. The yellow flower heads are several inches broad, somewhat resembling small sunflowers.

Inula grows, either indigenous or naturalized, in the temperate parts of Europe, Asia, and North America, and is also cultivated in Europe.

The root should be collected either in spring or in autumn, suitably sliced, and dried with gentle heat. It is then "in transverse, concave slices or longitudinal sections, with overlapping bark, externally wrinkled and brown; flexible in damp weather; when dry, breaking with a short fracture; internally grayish, fleshy, slightly radiate, and dotted with numerous shining, yellowish-brown resin cells; free from starch; odor peculiar, aromatic; taste bitter and pungent."

Composition.—*Inulin, helenin, alant camphor, alantol, essential oil, alantoic acid,* waxy, acrid, resinous, and bitter substances, besides ordinary vegetable principles and ash. The first of these, although of no medicinal properties, is the most interesting, and has received its name from this plant. It was discovered in it in 1804 by Valentine Rose, who also pointed out its intermediate position between starch and sugar. Since then it has been observed in the roots of nearly a hundred *Compositæ*, but in the plants of no other family excepting the *Lobeliaceæ*. It has likewise not been found in the aerial portions. The *alant camphor*, or *helenin*, is obtained by boiling the roots with alcohol, filtering, and adding cold water to the filtrate, when the helenin separates, upon standing, in fine needles; or it may be separated by distillation. It is a faintly odorous and nearly tasteless, volatile substance, insoluble in water, but soluble in ether, oils, and hot alcohol. The *oil* is a yellow liquid of mint-like odor, and contains alantol ($C_{10}H_{16}O$). Alantic acid is a crystalline substance associated with the oil.

Action and Use.—Although an old remedy, it can hardly be said that elecampane has any important place in modern therapeutics. It is a stimulant, stomachic tonic, and enjoys a slight reputation in the treatment of amenorrhœa and bronchitis. Dose, from 2 to 4 gm. (gr. xxx. ad ʒ i.) in decoction or infusion. *W. P. Bolles.*

ELECTRICITY: THE DESTRUCTIVE AND LETHAL EFFECTS OF HIGH-PRESSURE[*] CURRENTS.—There are delivered from the high-pressure line of a big transmission plant, at night glowing blue with the energy that is streaming off into the dielectric, perhaps thousands of kilowatts to distant transformers, which may serve to light a whole city or furnish power to operate a street-railway system. The one result or the other obtains according to the conditions of the conducting circuit; but, in both instances, it is energy which is delivered at the terminals, and which by its expenditure produces the different phenomena instanced.

In the application of an electric current to the human organism, whether administered therapeutically, encountered accidentally in the pursuit of one's avocations, or whether applied with intent to kill (electrocution), energy is expended within the tissues of the body, causing physiological change, pathological lesion, or destruction of life. The phenomena produced, whether for life, disability, or death, depend not alone upon the initial pressure, but upon all the conditions of the conducting circuit, *i.e.*, resistance electrical and vital, as well as position, superficies, and nature of contacts. A recognition of the oneness of this energy, whether of low or of high pressure, whether continuous or alternating in its direction, as well as the precise and definite laws under which it acts, conduces to an intelligent appreciation of the varying phenomena produced by its expenditure. A study of the action of an expenditure of energy from a high-pressure source or from a lower pressure, but capable under suitable conditions of producing injurious or destructive effects, involves an analysis of:

(1) Experiments made upon animals with a view to determine the cause of death;

(2) Of such accidents as occur in the use of industrial currents;

(3) Of the phenomena observed in the electrocution of criminals.

There is a considerable array of experimental work to be drawn from, going back to the time of Nollet, but much of it was conducted in a crude and unscientific manner, and is of little save historical value. The most careful and scientific work has been done within the past eleven years; and the conclusions reached by the different experimenters referred to in the following analysis point in almost every instance to a uniform action and set of conditions, although only interpreted by Prévost and Battelli and Cunningham.

Under the second head the evidence is not so conclusive as in the first and third. In accidents due to electric currents—by reason of the fact that they are accidents and occur unexpectedly—the precise conditions of the conducting circuit, as well as the phenomena pertaining to the mechanism of injury or death, are rarely observed with scientific accuracy. Still, considerable data have been accumulated, which, with the data of experimental work and those secured from the electrocution of criminals, suffice to further an intelligent analysis of the subject.

Under the third division—the electrocution of criminals—every opportunity is afforded to note exactly all the conditions of the conducting circuit, the pressure, the superficies, position and nature of contacts, the precise measurement of current in amperes, the time, the resistance, the power or watts, and the work or total expenditure of energy in joules. The opportunity also exists, if it could be taken advantage of, for obtaining definite, detailed, and scientific information as to how and when death occurs; as to consciousness and sensation; and also whether resuscitation would be possible by the immediate application of some special method; and it has been suggested that if the law recognized the right of science to have present a trained observer, with the privilege of using the necessary physiological apparatus in order to record graphically the phenomena which take place both during and after the passage of the current, as well as to make a careful study of the post-mortem findings, the result would be of incalculable value in determining the mechanism of death in man.[*]

The conclusions arrived at as to the manner in which death takes place in man are determined by inference from experimental work, from the accidents which take place in the electrical industries, and from electrocutions; but the data would be more absolute and trustworthy if procured in the way above alluded to, and yet at the same time no harm would be done to the individual suffering the penalty of the law.

Before entering upon a detailed account of experimental work, it would be well to consider the electrical conditions necessary to the production of injurious and lethal effects:

(1) What is to be understood by high-pressure currents in relation to lethal effects—*i.e.*, what voltage is necessary to the production of fatal results?

(2) Is it a matter of pressure—*i.e.*, volts alone, or is it a matter of current—*i.e.*, amperes as well?

(3) What influences the latter, the pressure only, or do high-pressure currents from position and nature of contact act as medium- or low-pressure currents?

An analysis of the experimental work (which will be considered more in detail from the physiological side later on) shows that currents of varying pressure have been used to produce a lethal effect in the same species of animals, while varying pressures are required for different species of animals.

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[*] In every instance in which authorities quoted have used the word "tension" in relation to an electric current, the writer has substituted "pressure" in order that the terminology may be exact.

[*] Cunningham: "The Cause of Death from Industrial Currents."

For example: Houston and Kennelly used pressures of from 690 to 1,250 volts alternating (experiments on dogs);* Bleile used from 50 to 100 volts alternating (experiments on dogs);† Kratter used 1,500 volts alternating (experiments on dogs, rabbits, and guinea-pigs);‡ Cunningham employed continuous currents of 115 volts pressure from lighting mains and 124 volts from a battery of accumulators (experiments upon dogs);§ while Prévost and Battelli conducted their experiments with both continuous and alternating currents and pressures varying from a low pressure of 120 volts to a medium pressure of from 240 to 600 volts, and high pressures of from 1,200 to 4,800 volts.‖ They used in their experiments dogs, guinea-pigs, rabbits, and rats. Bokenham and Jones, in their experiments made upon cats, reported the current, viz.: 0.5 ampere, but not the pressure;¶ Tatum used from 0.1 to 1.3 ampere; while Oliver and Bolam give only the physiological results obtained**—to which reference will be made later on,—but neither the pressure nor the current.

Kratter found that rabbits often survived pressures which proved fatal to dogs ten times the size, and Cunningham found it possible instantly to arrest the cardiac function in a very large dog—such as a Newfoundland—with a current of but 0.3 ampere; while the hearts of small, shaggy terriers, although considerably affected, not only withstood repeated shocks of 0.45 ampere, lasting from ten to eighty seconds, but quickly recovered from a shock of 0.7 ampere applied for two seconds and a half. In common with those of Prévost and Battelli, his experiments show that certain species of animals, frogs and turtles, do not succumb to currents of low pressure.

Prévost and Battelli established that with a pressure of 120 volts (alternating currents, contacts good—*i.e.*, one upon the head, the other upon the limbs) death resulted in certain animal species, while others (for example, rats) escaped without harm.

Kratter found that a short exposure to an alternating current of 1,500 volts did not always prove fatal to rabbits and guinea-pigs, while others succumbed presenting typical symptoms.

With currents of high pressure, Prévost and Battelli found that 1,200 volts (the contacts being good—*i.e.*, the one upon the head and the other upon the limbs) could kill all animals by inhibition of the respiratory centre; but that the pressure of the current and the duration of the contact should increase with the size of the animal in order to inhibit the respiratory centre. A rat, for example, succumbed to a pressure of 600 volts for one second, while a rabbit required 1,200 volts for two seconds. A dog of smallest size required 2,400 volts for three seconds, while a dog weighing 8 kgm. resisted a shock produced by the passage of a current of 1,200 volts prolonged for five seconds.†† Nor is the pressure fatal to animals, when acting as a high pressure, necessarily fatal to man.

Of equal importance with the pressure is the position, superficies, and nature of contacts. The latter may be of a material which is a good conductor, but by reason of imperfect contact they may act as a poor conductor, thereby increasing the resistance and diminishing the amperes; the same will be true if the contacts are dry instead of moist. With the skin well wetted with salt solution the resistance is lessened; and with diminution of resistance there is an increase in the amperes. In such a condition of the skin a greater amount of current is delivered to the tissues, producing a fatal result; whereas, if the skin had been dry and able to perform its function as an insulator, the resistance would have been so great as to have limited the flow in current below the lethal dose. A well-insulated contact also serves to increase the resistance and to minimize the current.

The superficies governs the distribution of current on the one hand, or its current density on the other. With large square-inch area of contact, the greater the current diffusion; with small superficies the greater the current density, within a localized area. These are factors of great importance and must never be lost sight of when considering physiological effect.

The position of contacts is of the greatest importance and largely influences the result. All experimental work, as well as what is observed at electrocutions, proves that fatal results ensue much more quickly when the contacts are so placed as to bring the heart, which is the vulnerable organ, on a line which unites the two electrodes—*i.e.*, directly in the conducting path; as, for example, on the head and calf of the leg. When they are placed on the head and fore legs, or in the case of man (electrocuted criminals) on the hands, a much greater pressure is necessary to destroy life. This is because the heart is not in the direct pathway of the current. When both contacts are placed upon the head, higher pressures are required to produce fatal results. Here, by reason of the skull, there is increased resistance; and, as the evidence shows that stronger currents, *i.e.*, greater amperage (see Houston and Kennelly, pressure 690 volts, R. 1,200 ohms, current 6 amperes, dog not killed), are withstood, the pressure must of necessity be proportional. As will be seen further on, the action of the current is different in a head contact than when the heart is included in the circuit. These facts all point to the chest directly over the heart, and to the dorsal region, as the better places for the contacts in electrocutions; but, as it is desirable that consciousness should be annulled at once, the posterior contact could be made to include the cervical spine, medulla oblongata, and the head.

Duration of contact, or time, is another important element. An instantaneous contact with a high-pressure current may be encountered with impunity, but a fatal result will ensue if an application of several seconds—five, ten, or more—be made; or, if a high-pressure current be applied for an instant of time and repeated, fatal results may ensue.

As to the amperage of a lethal current, it is not definitely known, but all the evidence obtained from experiments on animals and accidents with industrial currents show that it is very small—probably much under one ampere. In the application of the death penalty as practised in the State of New York, the strength of the alternating current passed through the body of the criminal is usually seven or eight amperes. In experimental work, the species, weight, and age of the animal have influenced the result, and the age of man, as well as the vital resistance in both man and animals, is a factor that must be considered in determining the lethal dose. In his experiments Cunningham found that young, well-nourished, and hardy dogs bore a stronger current than those older and ill-nourished, but that the size and weight seemed to bear no relation to the minimum current.

The nature of the pressure, whether continuous or alternating, is not without its influence. Cunningham found that alternating currents of moderate frequency, intermittent and coarsely pulsatory currents, were able to produce fibrillary contractions of the heart much more readily than a non-alternating or a continuous current. Tatum found alternating twice as fatal as continuous currents, but when the animal experimented upon was under ether the difference was much less marked. This would point to the influence of the powerful muscular contractions in the production of lethal effects; as, under the influence of anæsthesia, there would be a condition of general muscular relaxation which would tend to minimize this action. D'Arsonval believed that greater danger lay in accidental contact with a high-pressure, continuous E.M.F., because of the electrolytic phenomena which accompany the action of the current. The living body, in reality, is not a homogeneous conductor, and the polar action is produced not only at the points of entrance and departure of the current, but at the surface of each different tissue crossed by the current. This is an opinion—*i.e.*, as to the action of the current—which is shared by other physicists, although, as will be seen, Tatum concluded that there was nothing in the evidence obtained to show that any action on the blood was of the nature of electrolysis.

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* Houston and Kennelly: "Death by the Alternating Currents."

† Bleile, A. M.: "The Cause of Death by Electrical Shock."

‡ Kratter: "Lesions of Fatal Electrical Currents."

§ Cunningham: "The Cause of Death from Industrial Currents."

‖ Prévost and Battelli: "The Mechanism of Death by Electric Currents in Man."

¶ Tatum, Edward: "Death from Electrical Currents."

** Oliver and Bolam: "The Cause of Death by Electric Shock."

†† Battelli, Frederic C.: "The Mechanism of Death by Electric Currents in Man."

From the physiological action of high-frequency alternating currents of high potential as administered therapeutically, as well as from the experiments of D'Arsonval, Elihu Thomson and Tesla,* with currents of from 100,000 to 200,000 volts, with a frequency of 10,000 periods per second, it would be expected that fatal effects would occur in inverse ratio to the frequency—*i.e.*, that a low frequency, or periodicity, is more fatal to life than a high. The higher the frequency the greater the current which can be delivered to the tissues of the body without injury.

It is of interest here to note that alternating currents of high frequency, applied to the exposed heart, produce an increase in the number of beats and fibrillation does not occur; and that oscillatory currents of high potential very materially hasten the restoration of the coordinated heart beat in dogs in conjunction with the perfusion of the coronary vessels with defibrinated blood.†

The evidence clearly shows that high-pressure currents are not alone fatal—not even necessarily fatal; that low pressures—95 or 96 volts, and 115 volts, alternating current—are sufficient to cause death; and that while ordinarily pressures under 200 volts are not to be regarded as dangerous to life, and those over 500 volts as certainly dangerous, everything depends upon the conditions of the conducting circuit. In electrocution, to insure instantaneous and painless death, currents of high pressure are of necessity chosen.

Accidents in the electrical industries are not unduly frequent as compared with the accidents in other industrial fields; not because the pressures employed would not prove fatal under appropriate conditions, but because these conditions are but infrequently fulfilled.

In the electrocution of criminals, high-pressure currents varying from 1,300 to 2,000 volts—periodicity about 130—are commonly used, and an alternating current of 1,700 volts has traversed the tissues of the body (electrocution, Jaylor, 1893) without arresting the respiration even with an application of fifty seconds' duration, and second and third applications of the current were necessary in order to kill the condemned criminal. (This statement must not be construed as an implication that high-pressure currents do not kill, as used in electrocution at the present time, but is an illustration of the fact that a high-pressure current is not necessarily fatal. Other factors influence the result, as will be pointed out later on.) The case of Jaylor also illustrates the fact—brought out by the experiments of Prévost and Battelli—that when the pressure is high, even when the heart lies on the line which unites the two contacts—*i.e.*, within the conducting path,—this organ may not be affected, and that the nervous centres, continuing to be fed, are able to resist the action of the current; nor was the current traversing the tissues sufficient, in this case, to produce inhibition of the nerve centres, with definite arrest of the respiration. For the accomplishment of that result it was necessary to make a second and even a third application.

In the case of McElwaine (second electrocution), in which the points of contact were the head and arms,—the hands and forearms being immersed in jars of saline solution,—the effects were even less pronounced, and a second application, with the contacts applied to the head and calf of the leg, was found necessary in order to kill him. As in the case of Jaylor, the respiration was not affected by the first application. On the other hand, an alternating current of very much lower pressure—as low as 95 or 96 volts—has proved fatal in man; while several fatalities (four in number) occurred in a German mill* within a short space of time from an alternating current of 115 volts pressure.

In the death resulting from contact with an alternating current of from 95 to 96 volts, all the conditions of the conducting circuit were good (see No. 9 of the tabulated references to accidents from industrial currents). The subject, a workman in a potash and alcohol plant, was instantly killed by an alternating current of from 95 to 96 volts. He stood on an iron tank covered with soda lye—an excellent conductor—and his boots were wrapped with rags of twilled linen.† Here was the best of contact, for the saturation of the linen rags implied of necessity a similar condition of the leather of his boots, and no doubt conductivity was increased by the presence of nails in his boots, as is common among workingmen, although it is not so stated. The contact lasted for from four to five minutes, and the man was a drunkard. In this case, while the pressure was low, the resistance, by reason of position, superficies, and nature of the contacts, was reduced to a minimum and the current strength (or number of amperes) must necessarily have been high. In addition, the heart was in the conducting path, the duration of contact was prolonged, and the man was a drunkard. In this instance, then, everything favored a large electric energy, *i.e.*, a pressure, while low, fully effective because of low resistance, and resulting in large amperage; while long contact and diminished vital resistance, by reason of intemperate habits, contributed to the fatal result.

While there does not seem to be any direct connection between the lethal effect and the number of joules, there must be some remote effect, for the greater the energy the greater the chance of death. The conditions in the above instance favored the maximum rate of expending energy, the destructive power of which must have been increased, however, by the prolonged contact (three hundred seconds). The experiments of Prévost and Battelli show that the fatal effects are due to the energy, and that the energy required for killing a given animal increases in proportion to its weight. In a one-pound guinea-pig, 400 joules were necessary to arrest respiration; while in one weighing ten ounces, but 250 joules were necessary.‡

From experiments upon animals, accidents from industrial currents, and the electrocution of criminals, it is evident that the lethal effect is due to a sudden discharge. If the same amount of energy in joules was passed through the body slowly, the effects might be quite different. For example, 400 joules, the lethal dose for a one-pound guinea-pig, might mean a pressure of 20 volts, a current strength of 20 amperes continued for one second of time, *i.e.*, $20 \times 20 \times 1$ volt-ampere seconds $= 400$ joules; or $20 \times 0.1 \times 200$ volt-ampere seconds $= 400$ joules. The result would be very different in each instance. In the first, a sudden discharge of great power; in the second a gradual expenditure of energy, lasting for two hundred seconds, and accomplishing the same amount of electric work, but not violent nor disruptive in its action, as in the former instance.

This detailed case, as well as experimental work and the electrocutions instanced, show that the pressure necessary under one set of conditions is not required under another, and that a lethal dose does not of necessity require a current of high pressure. Prévost and Battelli found that under good electrical conditions, a dog—contacts head and hind limbs—could be killed with a current of 10 volts pressure; while 80 volts were necessary, under the same conditions, when the contacts were made to the head and fore-legs. In the former instance, the heart lay in the conducting path, while in the latter it did not, and was not only reached indirectly—requiring more power—but, by reason of increased resistance, a greater pressure was required to secure the current necessary to the production of a lethal effect.

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* Thomson, Elihu: "Effects of High-Frequency Electrical Discharges passed Through the Body." Tesla, Nikola: "Alternating Currents of High-Frequency and High Potential."

† Cunningham: "The Cause of Death from Industrial Currents."

* Battelli, Frederic C.: "The Mechanism of Death by Electric Currents in Man."

† Kolben: Elek. Zeit., February 15th, 1900.

‡ Prévost and Battelli: "The Mechanism of Death by Electric Currents in Man."

This experiment illustrates the influence of the position of the contacts, as does also the case of McElwaine (second electrocution), in whom the head and hands formed the points of contact. In this instance the contacts were good—*i.e.*, saline solution—and there was a large superficies; but, by reason of their position, they were objectionable for the purpose contemplated, in that the heart was not placed in the conducting path, and consequently death did not result until their position was changed.

It is clearly shown, therefore, by an analysis of the work of different experimenters as well as of the accidents from industrial currents, that lethal effects follow contact with pressures of widely varying E.M.F.

An accidental contact with a high-pressure line or terminal—or with any pressure for that matter—rarely involves the same set of conditions, and often the conditions existing are such as to render it ineffective as a high-pressure current. Favorable conditions are obtained only (1) in experimental work, and (2) in electrocutions. It is not then a matter of pressure alone, for death results from currents of low pressure as well as from those of high pressure, and the latter are oftentimes ineffective, while a fatal result may follow contact with a low-pressure current.

Cases 3 and 10 (see tabulated references) illustrate the inefficacy of a high-pressure current with poor contacts; while No. 9 is a striking example of the efficacy of a low-pressure current with the best position as well as nature of contacts; and it is not only a question of diminished electrical resistance, but of vital resistance (see Case 9) as well.

There can be no doubt that vital resistance must be counted as one of the conditions governing the action of a lethal dose. Kratter, in his experiments, found that a short exposure to an alternating current of 1,500 volts did not always prove fatal to rabbits and guinea-pigs, while others succumbed. With all the conditions of the conducting circuit absolutely the same, and with animals of the same species, age, and weight, this would indicate to the writer a difference in vital resistance—a factor which cannot be lost sight of in the administration of a lethal dose of electricity any more than in its therapeutic administration.

Cunningham, in his experiments, established the fact that anything acting to depress the vital forces increases susceptibility to the current. For example, after the cervical cord in an anæsthetized dog had been exposed and divided, it was found that a very brief passage of a current of 0.25 ampere caused the heart to stop immediately, although previously one of 0.65 ampere had been readily withstood. Whatever serves to depress the general condition increases the susceptibility even to weak currents.

From the action of a low-pressure current, when the effect is upon the heart (*i.e.*, causes fibrillar contraction), it is seen that such animal species as rats, frogs, and turtles recover spontaneously, whereas in the higher order of mammals, as well as man, death is absolute; but that from currents of a higher pressure death results in the former with a lower pressure and shorter contact than in the latter. This is when currents of high pressure act by reason of position and nature of contact as such.

The spontaneous recovery of such animals as rats, frogs, and turtles depends upon the phenomena connected with the heart. The action of a low-pressure current is more severe and more lasting as the animal kingdom is ascended. The cold-blooded animals recover from the action of the current on the heart, while the warmer-blooded animals succumb. The heart is paralyzed in ventricular tremulations in all animals, and the phenomenon produced varies in intensity according to the genus of the animal. Prévost and Battelli used four genera of warm-blooded animals:

(1) Dogs, in which the characteristic action in the heart (ventricular tremulations) is well defined.

(2) Guinea-pigs—adults—in which the tremulations were most often, but not always well defined.

(3) Rabbits, in which the tremulations are oftenest transitory, but in some cases well defined.

(4) Rats, in which the tremulations last only during the electrization of the heart. When this ceases the tremulations disappear and the ventricles resume their beat."*

These observations are in accord with the well-known physiological fact that while the hearts of the higher mammals very rarely recover spontaneously from a condition of fibrillar contraction, the hearts of those lower in the animal kingdom and of cold-blooded animals do; that in them a lethal effect must be produced by asphyxia, and necessitates the use of a current of higher pressure.

Results of Experimental Work, Physiological.—There is a wonderful similarity of result in retrospect of the work of different physiologists made within the past eleven years to determine the mechanism of death, although the earlier investigators did not carry their experiments to the definite conclusions of the later ones, and in some instances failed to appreciate and interpret correctly the phenomena observed. By far the most important experiments, and the only ones to which reference will be made—others having a purely historical interest—are those of (1) D'Arsonval, 1887; (2) Edward Tatum, Physiological Laboratory of the University of Pennsylvania, 1890; (3) Houston and Kennelly, Private Laboratory, Philadelphia, Pa., 1894 (undertaken not to determine the mechanism of death, but whether death did occur as the result of pressures similar to those used in electrocutions in which contacts were good, in order to refute the idea that in electrocution the current did not kill, and that the autopsy did); (4) Bokenham and Jones, Laboratory of the Royal College of Physicians and Surgeons, London, 1895; (5) A. M. Bleile, Physiological Laboratory, Ohio State University, 1895; (6) Kratter, 1895; (7) Oliver and Bolam, 1897; (8) Prévost and Battelli, Physiological Laboratory, University of Geneva, Switzerland, 1899; (9) R. H. Cunningham, Physiological Laboratory, Columbia University, 1899.

As a result of the experiments upon animals, of a study of accidents from industrial currents and from atmospheric electricity, and also of electrocutions, the generalization is obvious that death due to an expenditure of electrical energy within the tissues occurs in two ways: (1) By mechanical lesions of vital structures, or (2) by arrest of organic functions essential to life—*i.e.*, by arrest of respiration, heart's action, or nutritive exchange.

Death occurs, as a rule, in the first way, from lightning stroke, and there is an actual mechanical disintegration of vital structures. This is, however, not always the case. The deaths from lightning in this country are happily very few, being estimated at only about one per million of the population per annum. Oftentimes no trace of injury can be seen upon the subject of the accident, but in other cases various marks are found upon the body, or the clothing will be torn or scorched; and it not infrequently happens that the boots are torn off the feet, and nails driven out of the soles of the boots. The following case illustrates, in a striking manner, the disruptive action of this tremendous energy:

The accident occurred in Guilford, England, August 25th, 1897, and the inquest revealed that the man was found, one-half hour after a single flash of lightning and a clap of thunder, lying on his face. Around him, within a radius of several yards, were his clothes and boots, which had been torn and scattered about in an extraordinary manner. The lightning appeared to have struck him on the right side of the head, tearing his cap to pieces and burning his hair off. It then passed inside his collar, down the front of his body and both legs into his boots, which were torn to pieces, and then it passed into the ground, making a hole about eighteen inches in circumference and three inches deep. His collar was torn to pieces, the front of his shirt was rent into ribbons, the jacket and undervest were literally torn to shreds, and the knickerbockers he was wearing were stripped from him and scattered on the ground. His stockings and gaiters were similarly torn to pieces, and on the boots the lightning had a remarkable effect. They were burst open, some of the brass eyelet holes were torn out, nails were forced out, and the soles were torn out. The skin had been torn off the chest and the right leg was torn and blackened; blood was issuing from the mouth and right ear.[*]

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* Battelli, Frederic C.

In view of the fact that the current strength of a particular stroke of lightning, from the data presented, has been estimated at at least hundreds if not thousands of amperes, it is not difficult to account for the phenomena described.[†]

There is no doubt that a lightning stroke acts sometimes as a high-pressure current, *i.e.*, it causes an inhibition of the respiratory centre and syncope, and it is in such cases that recovery follows either spontaneously or from artificial respiration. That death occurs sometimes in the first way from industrial currents is unquestionable, and the post-mortem findings in some of the electrocutions point to an actual mechanical disintegration of the vascular structures; at least, such seems to have been the case in the twenty-fourth electrocution (Hampton) witnessed and reported by Drs. A. E. Kennelly and Augustin Goelet.[‡] In this case, upon post-mortem examination, it was observed that the blood was driven from the peripheral vessels into the organs and tissues of the chest and head and there was actual rupture of the overdistended vessels. Examination of the brain demonstrated the presence of a quantity of dark blood due to rupture of the blood-vessels. It was estimated that at least two quarts escaped from the scalp and cranium in removing the brain. Upon the removal of the dura mater the vessels on the surface were seen to be distended, while in many places there were evidences of rupture. The same condition existed in the interior of the brain and coagulated blood was found at the base of this organ.

As to the actual mechanism of death occurring in the second way, for a long time there was no uniformity of opinion among physiologists. Happily, more solid ground seems now to have been reached.

In reviewing the work of the different experimenters in sequence, it is found that D'Arsonval concluded from his observations of the phenomena which took place in animals subject to lethal doses of electricity, that death occurred in two ways:

(1) By lesion or destruction of the tissues (disruptive and electrolytic effects of the discharge).

(2) By excitement of the nerve centres, producing the arrest of respiration and syncope, but without material injuries. In the first instance death is absolute and final, but in the second he believed that the nerve centres—respiratory—were inhibited, which gave rise to a suspension of respiration and arrest of heart action. In his estimation the primary action was upon the respiratory function, and the cardiac failure followed upon exhaustion of the medulla oblongata and functional death of the ganglionic cells. The fact of cardiac action after arrest of respiration led to this theory.

(3) Tatum concluded that the essential fatal field of action lay within the substance of the heart itself; that the external inhibitory mechanism played little or no part; that electrical currents finally arrest respiration without simultaneous or still earlier arrest of the heart; and that no changes were observable in the substances or functions of the muscles and nerves or blood which could in any sense be the cause of sudden death. He offered no explanation as to the nature of the action on the heart, but, from experiments with curare and atropine, he believed that the action was a direct one upon the muscular tissue rather than one involving any nervous mechanism. He had no suggestion to offer as to why the heart muscle was more susceptible than other muscles, but hoped that a more special study of the subject would soon be possible. That hope has been fulfilled in the work of Prévost and Battelli and in that of Cunningham.

(4) The experiments of Houston and Kennelly have already been referred to as of interest, not from the physiological side, but in demonstrating that death is practically instantaneous and painless from the purposed and scientific applications of high-pressure currents. They showed, as Tatum had,—and this has been confirmed by later investigators,—the tolerance of an animal to currents of high pressure when passed through the head (contacts consisted of cotton pads well wetted with saline solution and placed in the ears of a dog; alternating current of 700 volts, 690 of which were effective; resistance 1,200 ohms; current 6 amperes; duration five seconds; loss of consciousness, but animal not killed). Their conclusions as to the instantaneity and painlessness of death will be considered later on.

(5) Bokenham and Jones confirmed the observations of Houston and Kennelly, that a much stronger current was required to kill an animal (the experiments were made upon cats) when passed through the head or when the contacts were placed on either side of the neck. The pulse tracings taken by Bokenham and Jones, and careful inspection of the respiratory movements, led them to conclude that death was caused by failure of the heart, and the negative results of shocks of equal strength passed through the head and neck strongly suggested to them that the action was upon the heart muscle directly rather than through the nervous mechanism.

(6) Bleile, after a series of very carefully conducted experiments, eliminated during their progress (1) the direct action of the current upon the heart, by artificial respiration; and (2) the influence of the pneumogastric nerve, by the hypodermic injection of atropine, thus paralyzing the nerve fibres. He also, (3) prior to the application of the current, administered nitroglycerin and nitrite of amyl to produce dilatation of the arterial system. He then concluded that death was due to the contraction of the arteries, through the influence of the nervous system, and that the constriction of the arteries furnished a greater mechanical impediment to the flow of blood than the heart was able to overcome.

(7) Kratter concluded from his experiments that the first effect consisted in a permanent arrest of the respiration and he regarded death from an electric shock as a form of suffocation.

(8) Oliver and Bolam concluded that the action was upon the heart muscle rather than upon any of its nervous mechanisms. They observed that when the current ceased to pass, the heart underwent distention and then entered into a state of *fibrillary tremor*, maintained for a variable period, while the animal would make deep, respiratory efforts—shown by forcible movements of the diaphragm. They failed, however, to interpret the value of this phenomenon, although they were the first to record it in connection with experiments made to determine the mechanism of death.

The analysis of the work of the physiologists thus far recorded points with three exceptions to a direct action on the heart as the cause of death. But it remained for Prévost and Battelli and Cunningham to show how the current acted on the heart muscle. Their experiments seem to have been conducted simultaneously and without knowledge on the part of either one as to what the other was doing—as is so often the case when scientific investigation of any sort has been carried to a certain definite conclusion—but the priority of publication belongs to Prévost and Battelli (Comptes Rendus de l'Académie des Sciences, March 13th and 27th, 1899; *Jour. de Phys. et de Pathol. Générale*, May and September, 1899—et *Revue Médic. de la Suisse Romande*, September, 1899; R. H. Cunningham, N. Y. *Med. Jour.*, October 21st, 28th, 1899.[*]

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[*] The Electrical Engineer, October 21st, 1897.

[†] Wurtz, Alex. J.: "The Current Strength of a Lightning Stroke." The Electrical Engineer, October 27th, 1898.

[‡] Kennelly and Goelet: "Does Execution by Electricity Produce Instantaneous, Painless, and Absolute Death?" Electrical World, vol. xxv., p. 195.

[*] Cunningham's article was completed toward the end of February, 1899, but was held back until March 31st, when it passed into the hands of one of the Prize Committees of the College of Physicians and Surgeons, New York, where it remained until published.

The experiments of Prévost and Battelli are no more conclusive as to the action of a lethal dose, but are more complete in that they deal both with continuous and with alternating currents of varying pressures, thereby establishing very clearly the apparent discrepancies in the action of low- and high-pressure currents. The experiments of Cunningham, on the other hand, were made with continuous currents only, at pressures of 115 volts (lighting mains), and 124 volts (battery of accumulators*).

Prévost and Battelli determined from their observations that the mechanism of death from both continuous and alternating currents was the same, although the action varied in a slight degree.

From their researches they find that death by electric currents takes place in two ways entirely different the one from the other:

(1) By the action of a low-pressure current, death in man is due to the primary paralysis of the heart in *ventricular tremulation*. This is regarded as the usual cause of death in accidents of the electrical industries, because, as has been pointed out, the conditions of the conducting circuit are such that a high-pressure current acts as a low-pressure current.

(2) A high-pressure current, when the contacts are good and the heart lies upon the line which unites the electrodes—*i.e.*, in the conducting path,—does not paralyze the heart of man. In this case the respiration has been resumed, as has been noted at the earlier electrocutions in New York State.

When death takes place, under the conditions just mentioned, it is due to an inhibition of the respiratory centre. The heart continues to beat with energy and stops only after the asphyxia. It is in these cases that it is sufficient, as a rule, to practise artificial respiration.

The paralysis which occurred in animals the subject of experiment, through the action of a low-pressure current, *i.e.*, 120 volts, they found "analogous to that which is directly obtained from exciting the exposed heart with an induced current, *fibrillary tremulations* of the ventricles, while the auricles continued to beat. This is the well-known phenomenon designated by physiologists as *ventricular tremulations* or *fibrillar contraction*."

A. The following phenomena were observed by them in their experiments upon dogs, cats, guinea-pigs, rabbits, and rats:

Alternating Currents.—"1. Instantaneous paralysis of vagus and of cervical sympathetic with currents of high pressure.

"2. Non-modification of phenomena described above by previous section of vagus nerves.

"3. The repletion of the heart with blood, even in the case of currents of high pressure and short duration, which seems to prove that the vascular tone and vasomotor centres are not paralyzed.

"4. No appreciable elevation of the temperature, if the time of the passage of the current is not prolonged.

"5. Rapid appearance of cadaveric rigidity in the case of the currents of high voltage.

"6. At autopsy, absence of constant and characteristic microscopic lesions. Notwithstanding, one finds sometimes hyperæmia of the meninges, but not intracerebral hemorrhages, if the subject of the experiment has not been subjected to elevation of the temperature.

"7. *Duration* of the contact is important; respiration, *cœteris paribus*, is more affected when contact has been longer. Convulsions and general tetanus will be more pronounced if the contact has been short. The more the voltage is raised, the shorter is the duration of the contact necessary to cause convulsions.

"8. The *points of application* of the electrodes are a matter of great importance. Their differing position can vary the appearance of this or that symptom.

"*Respiration* will be affected more easily and convulsions more easily produced if one of the electrodes is placed upon the head.

"*Heart.*—The voltage necessary to produce the *fibrillary tremor* is less if the heart is in the line between the poles. Inversely, if the heart is not in this line, it can be thrown into *fibrillary tremor* (*tremulations fibrillaires*) upon the application of currents of high pressure, which, in traversing the heart directly, would not have paralyzed it.

"9. When, after currents of high pressure, the heart of the dog or of the guinea-pig is paralyzed consecutively to the arrest of respiration, *massage* of the heart provokes the *tremulations fibrillaires*, which are wanting in a case of simple asphyxia not produced by electrocution.

B. *Continuous Currents.*—Conclusions reached:

"1. *Respiration* and *sensibility* react the same to the shocks of closure or of opening.

"2. *Convulsions*, on the other hand, are especially provoked by opening of the current.

"3. As to the *heart*, the fibrillary tremor will come on if the circuit be not closed or opened abruptly. It is a fact, analogous to that which was stated with regard to alternating currents, that a violent excitation can make the fibrillary tremor cease.

"4. Examination of the tracings of arterial pressure seems to indicate the absence of a vaso-motor excitation, which, on the other hand, is produced by the alternating currents."

The fact that in some of the earlier electrocutions in New York (McElwaine, Jaylor) respiration was not definitely arrested when the body was traversed by a pressure of 1,700 volts alternating current (contacts good, head to leg, continued for several seconds), is in a line with some of the experiments of Prévost and Battelli. For example, a large-sized dog was submitted to the action of an alternating current of 4,800 volts (contacts good, duration several seconds), and yet spontaneous recovery of the respiration took place. On the other hand, in their experiments with a much lower pressure (240 to 600 volts, as well as with those of H. and K.) death was absolute. They found in dogs that these currents of medium pressure produced not only paralysis in ventricular tremulations of the heart, but also absolute arrest of the respiration. In such cases instantaneous death would result from the inhibition of the nerve centres, seconded by the failure of the circulation. In the first instance a repetition of the shock is sufficient to produce a definite arrest of the respiration, and while physiologically death cannot be regarded as strictly instantaneous, it is practically so so far as consciousness is concerned.

In view of the unquestioned fact that currents of the same degree of pressure and applied under apparently the same conditions, both in man (electrocutions) and in animals, produce such different results,—lethal in the one case, and non-lethal in the other,—we are justified in concluding that there must be differences in vital resistance. It is very evident from all the evidence forthcoming that the human respiratory system offers a very great resistance to an electric shock, and this resistance is by no means the same in all individuals, just as experiment has shown that it is not so in all animals. The fact that the nervous system is of a higher organization in man than in animals is suggested by Prévost and Battelli as a reason why the function of the respiratory centre should be abolished in the former with but a slight increase of voltage. This is not substantiated, however, by the results of electrocution. Prévost and Battelli show by their experiments upon animals that, all other things being equal, the higher the pressure the greater certainty of the definite abolishment of the respiratory function, and they place the pressure necessary for the purpose beyond 1,700 volts.

So far as the evidence is at hand from the electrocutions which have taken place in New York—some fifty in number—it appears that the expenditure of this tremendous energy varies in its action in different individuals; that while in one a complete inhibition of the respiratory centre from a single application results, in another several successive shocks are required completely to abolish its function; and again, in other instances, there seems to be an actual mechanical disruption (twenty-fourth electrocution), as the blood from every peripheral as well as from the larger vessels is forced by the powerful tetanic, muscular contractions into the chest and head, with rupture of some of the blood-vessels. It is fair to suppose that nearly all the energy liberated in the body is expended as heat; and, as a matter of fact, there is a considerable rise in the temperature, although the action of this heat does not bring about death. In this connection it is interesting to note that Prévost and Battelli found that there was no intracerebral hemorrhage when the temperature was not raised, which would seem to indicate a definite relation between the amount of energy liberated and the result.

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* Cunningham made some experiments in 1894 with currents of a higher pressure, but the detailed results are not embodied in his paper of October 21st, 28th, 1899.

If this energy acted to produce either inhibition of the respiratory centre or paralysis of the heart in ventricular tremulation, there might not be an appreciable rise in the temperature; but when it has acted to produce a disruptive effect, as, for example, in some accidents from industrial currents and sometimes in electrocution (*i.e.*, with excessive intracerebral hemorrhage and rupture of some of the blood-vessels), the evidence shows that the rise is considerable.*

Analysis of the accidents from industrial currents (presented farther on in tabulated form) would seem to confirm the experiments of Prévost and Battelli in reference to the action of the current on the respiratory centre.

In cases 2, 3, 8, and 10, there was contact with alternating pressures of 2,000, 4,500, 10,000, and 25,000 volts respectively, followed by recovery. From the conditions of the conducting circuit (*i.e.*, position and nature of contact) No. 2 was evidently a hand-to-hand contact; No. 3, bipolar, *i.e.*, telephone wire grasped in hand, which touched another wire; No. 8 a hand-to-hand contact; and No. 10 a hand-to-hand contact (the energy was not expended upon the respiratory centre in such a way as definitely to arrest respiration, nor was the heart in the direct conducting path). To produce inhibition of the respiratory centre, a head-to-spine contact is the most favorable, although a head-to-leg contact contributes to the same result. The latter position of contacts also favors action upon the heart primarily, although a chest to spine, or to spine and head, is better. Had the latter condition obtained in No. 10, on account of the very high resistance offered by the position and nature of the contact, the pressure, although high, might have acted as a low-pressure current to paralyze the heart in ventricular tremulations.

The data in Cases Nos. 1, 9, 11, 12, 13, 15, 16, and 20 seem corroborative of the experimental work of Prévost and Battelli, showing that high-pressure currents, by reason of high resistance, act as low-pressure currents. Although the pressure in every one of these instances was high, the inference is reached, from instantaneous death, that they acted by reason of position and nature of contact as low-pressure currents, and that death was due to paralysis of the heart in ventricular tremulation. Unfortunately there has never been any opportunity of observing this phenomenon in man, and the inference can be drawn only by the action on warm-blooded animals. By reason of the fact that in the industries the contacts are always bad, both as to position and as to nature, the resistance great and amperage small, the effect produced is that of a low-pressure current. This effect is more grave when the initial pressure is high,—less so with a diminution of voltage.

It is not believed by Prévost and Battelli that the paralysis of the heart in man is always permanent, but that it may sometimes be transitory. This conclusion is reached by them as the result of an analysis of some accidents, and from the fact that the current does not affect all animals similarly; that in some—for example, a guinea-pig—the heart rarely resumes its beats, but that in the rabbit it often resumes its rhythm. These are inexplicable facts, and we have no means of knowing that the human heart may not comport itself similarly.

From experimental evidence there is every reason to conclude that besides the influence exerted by the quality, duration, strength, and density of the current (Tatum) through the thorax, some other factor, apparently residing in the heart and probably physiological in nature, also exercises a considerable influence, as evidenced by the greater or less readiness with which the cardiac effect is produced (Cunningham).

Prévost and Battelli as a result of their very complete experimental work, arrived at the following conclusions:

Conclusions and General Considerations.—Experiments upon animals, observations made upon the electrocuted criminals in America, the accounts of accidents occurring in the electrical industry, lead us then to conclude that according to all probability:

1. The heart in man comports itself like that of animals; it is paralyzed in ventricular tremulations by a current of low pressure.
2. The death of man, in the accidents of the electrical industry, cannot be attributed to arrest of respiration considered as an immediate cause.
3. The death of man in these accidents is due to the primary paralysis of the heart in ventricular tremulations.
4. Currents of high pressure, when the contacts are good and the heart lies upon the line which unites the electrodes, do not paralyze the heart of man; in this case the respiration is resumed, as has been observed upon the electrocuted criminals in America.
5. In the electrical industry the contacts are always more or less bad; for this reason the currents of high pressure act like currents of low pressure and lead to paralysis of the heart.
6. The difference in the results (mortal or not) of the grave accidents of the electrical industry can be explained in two ways: we must assume that the duration of the contact has been too short (fractions of a second) and that the heart has not been placed in ventricular tremulations; or we must admit that the paralysis of the heart of man is not always decisive, *i.e.*, permanent.

From these conclusions it would appear that in employing a current of high pressure, for the purpose of electrocuting a man, we have secured a result quite different from that which we set before ourselves to obtain, viz., to kill the man rapidly.

The study of the ventricular tremulation of the heart, which hitherto has offered only a theoretic interest, now assumes some practical importance; for it is to the development of these tremulations that are due the mortal accidents in the electrical industry. The physician, in most of these accidents, is quite impotent, for we possess no *practical* means of re-establishing the beats of the paralyzed heart. Artificial respiration, absolutely useless in the case of well-defined paralysis of the heart, can be sometimes of some use if this paralysis is transitory, in facilitating the normal resumption of the respiration. In any case, artificial respiration is actually the only treatment which the physician has at his disposition.

Cunningham in his experiments reached practically the same conclusion, at about the same time as, and independently of, Prévost and Battelli. The evidence obtained as a result of his experiments upon a series of thirty dogs is most conclusive, and his work, after a lapse of two years, may be regarded as classic. In view of this fact, a somewhat detailed description of his technique as well as of the results which he obtained, is of sufficient importance to warrant us in publishing it in the present article.

A medium-sized dog was etherized and into the right carotid artery there was inserted a cannula which was connected with a Ludwig manometer. The latter in turn was so arranged that the pulsations should be recorded upon the paper of a Hürthle kymograph. A second cannula was introduced into the trachea; and through this the anæsthetic was administered when necessary. As a third step the hair over the chest was carefully removed by shaving, and the scalp and soft parts covering the skull and temporal fascia (on both sides) were dissected off. Then, finally, the contacts, covered with thin chamois skin and well wetted with a strong, hot saline solution, were applied to the two regions thus made ready for them: to that of the heart a plate electrode, connected with the negative terminal and held securely in place by means of strips of rubber plaster; to that of the head a cup-shaped electrode connected with the positive terminal. A stethograph was attached to the chest and connected with a recording Marey tambour. A chronograph placed in shunt with the circuit that passed through the dog served to inscribe the base line of the tracings as well as to mark the closing and the opening of the circuit. A second chronograph indicated the time in two-second intervals, while a Whitney dead-beat voltmeter and a Weston dead-beat ammeter were used to measure the pressure and the strength of the currents. Normal tracings of the blood pressure and the respiration were first taken and then the circuit was suddenly closed and kept closed for seventy-six seconds. During its closure there was observed a pressure of 116 volts and an observed current of 0.4 ampere. The following effects were noted: Almost simultaneously with the closing of the circuit the blood pressure rapidly fell to zero, the tracing showing a few heart beats—auricular. At the closure a deep inspiration was produced, then there was a deep expiration, followed by cessation of respiratory movement in a state of expiration so long as the current continued to pass. On breaking the circuit a deep inspiration followed by an expiration resulted, and after a few moments a few shallow respirations were observed. Artificial respiration was then begun and was continued without avail for twenty minutes.

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* D'Arsonval and Brown-Séquard regarded the rise in temperature in part as the result of the asphyxia.

The occurrence of natural rhythmical respiratory movements after the opening of the circuit demonstrates that the respiratory centre in the medulla is not paralyzed nor instantly killed. Further, the tracings show that an almost total and instantaneous extinction of the arterial circulation is produced. By opening the chest previously and observing the behavior of the heart, it is readily demonstrated that this extinction of blood pressure results from a practically instantaneous cessation of the co-ordinated rhythmical movements of the heart at the instant a current of 0.9 ampere or even less is passed through a dog. Both ventricles immediately stop beating, while the auricles, especially the auricular appendages, beat with extreme rapidity. On stopping the current the auricular appendages generally resume their usual co-ordinated rhythmical contractions, which may often continue for a considerable number of minutes. Frequently the auricles will begin to beat again co-ordinately for a few seconds, but the ventricles rarely if ever exhibit the slightest sign of co-ordinated contraction. Cunningham noted ventricular contraction in only a single instance, and that only after he had introduced a tube into the jugular vein for the purpose of withdrawing venous blood from the greatly distended heart. This points to a direct action upon the ventricular portion of the heart muscle. The only difference observed, when the points of contact are the chest and fore-leg, instead of the head and chest, is the greatly exaggerated respiration shown by the resultant tracings. Upon opening the thorax immediately after the passage of the current through the heart percutaneously, a careful examination of the still quivering ventricles shows that the co-ordinated beat of the heart is absent, as a whole, while the various minute bundles of muscle fibres alternately contract and relax with considerable vigor in various parts of the ventricles. As the right cavities of the heart become more and more distended by the accumulating venous blood, the asynchronous quivering of the various little bundles of muscle fibres grows less and less until finally every trace of muscular contraction disappears from the greatly distended ventricle. The action of the current, Cunningham concludes, produces upon the heart the well-known phenomenon described by physiologists as *delirium cordis* or *fibrillar contraction*, "supposed to be caused by some change in the muscular fibres themselves," and Hedley * asks: Is this a coagulation by the heat, resulting from the tetanic muscular contractions?

Cunningham believes that there is no question of the instantaneous death of the muscle cells of the heart nor of their paralysis, nor of profound molecular changes invisible under the microscope, resulting from the direct disruptive action of the current. This, he says, is readily proved if Porter's method, or any other method for recovering the excised dog's heart from the condition of fibrillar contraction, is employed. By the use of Porter's method (perfusion of the blood-vessels of the heart with warm, defibrinated dog's blood diluted with 0.8 per cent. saline solution) the excised hearts (still manifesting fibrillar contractions) of numerous electrocuted dogs were made to beat co-ordinately again and to continue their co-ordinate contractions for nearly an hour, only ceasing then because of the discontinuance of artificial respiration. It was often necessary to plunge the excised hearts into iced saline solutions in order to stop all movements before co-ordinate beats could be established. These facts demonstrate that the heart muscle is not paralyzed or killed by the current; for if it were paralyzed no movements would have been observed after the passage of the shock; and if the muscle had been killed no recovery could have occurred on restoring the circulation. It is probable that "the effect of the electrical stimulus has been to disturb the balance of the hypothetical intracardiac co-ordinating mechanism, the nature and location of which physiologists are still endeavoring to elucidate."

Cunningham points out, as did Prévost and Battelli, that it is well known that the action of various kinds of stimuli upon the exposed mammalian heart—for example, mechanical, chemical, electrical,* and also the stimulus of cold—produce the condition known as fibrillary contraction; consequently the effect is physiological in nature and not one that is characteristic alone of the passage of an electric current.

In view of the fact that an electric current produces this effect upon the exposed heart, it is not at all remarkable that a strong electric current, continuous or alternating of a moderate frequency, when passed percutaneously, should throw the heart into a condition of fibrillar contraction.

H. Dixon Mann concluded, from the phenomena observed as a result of percutaneous applications of the continuous current upon man, that a struggle takes place between the natural and the artificial electrotonic conditions; and that when the heart is weak and the current strong, the heart is overcome, but that when the organ is fairly strong and active it is able to bear the force of the current without experiencing any harm.†

The experiments of Cunningham, as well as those of Prévost and Battelli, are conclusive in showing that death in dogs—and without doubt also in man, in view of the evidence of autopsies—from low-pressure currents (120 volts), or from those of medium pressure (240–600 volts), or even from currents of high pressure (above 600 volts), when the conditions of the circuit are such as to cause a high-pressure to act as a low-pressure current, is due to the excitation of fibrillar contractions from which the heart of the mammalian rarely recovers. The fact that certain animals (frogs and turtles, for example) recover easily from such a condition explains why they are not easily killed by low-pressure currents, and that to cause death, in these animals, the production of asphyxia by the use of high-pressure currents would be necessary.

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* "The Pathology and Treatment of Electric Accidents." London Lancet, August 25th, 1894.

* Weber, Ludwig, and Hoffa, for magnetic electric currents; Einbrodt, Mayer, Herbst, and McWilliams, for continuous currents from batteries and small induction coils. All of these authorities are cited by Cunningham in his treatise.

† "Action of Electric Currents on the Heart in Living Subjects."—The phenomena have also been observed by the present writer in therapeutic administrations of a continuous current when the heart was the subject of disease—mitral insufficiency—and the dose was increased beyond the tolerance of the patient. The symptoms were anguish, præcordial distress, and threatened syncope, with an irregular and feeble pulse. In view of the action of oscillatory currents of high potential previously alluded to, it is interesting to note that relief was promptly established by a general application of the convective discharge from a large influence machine with a localization directly over the heart and to the dorsal spine.

In determining the action of a strong, continuous current upon the cranio-cervical portion of the nervous system, Cunningham placed the contacts directly upon the exposed brain and spinal cord, thereby minimizing the resistance and acting directly upon the nerve centres. The passage of a current of 1.1 amperes for one minute directly through the cerebrum, medulla, and upper cord resulted in the usual deep inspiration followed by expiratory standstill, while the current was still flowing. If the current was not kept applied for too long a time, the respiratory movements generally recommenced a few moments after its removal. At first these movements were feeble, but gradually they resumed their normal rhythm, if the electrode had not been pressed with undue force against the brain. Even when the dose was 1.6 amperes, after the current had been on for several seconds, respiratory inhibition was overcome and pronounced respiratory movements began while it was still flowing. As a rule, however, inhibition of the respiratory centre during contact was maintained by a current of 1.5 amperes.

The blood pressure behaves differently when the contacts are directly against the brain and spinal cord, from what it does when they are placed simply against the head and chest;—*i.e.*, after a slight rise coincident with the general tetanic spasm of the muscles, produced always by the closure of the circuit, the pressure falls slightly; it then rises to a considerable height, often twice or thrice its original height, if the circuit is kept closed for fifty seconds. If the current is broken at this time it may or may not continue to rise for a few moments, but after this it quickly returns to the normal. On the other hand, if the flow of the current is continued for four or five minutes the blood pressure slowly diminishes, the cardiac action becomes progressively more labored and slower, and finally ceases. If artificial respiation is maintained, this enormous rise in the pressure does not take place. If the current is discontinued after the lapse of a minute, the inhibited heart action gradually disappears and respiratory movements, at first slow, soon become natural.

The asphyxia from inhibition of the respiratory centre appears to be mainly responsible for the increased blood pressure.

These experiments demonstrated the ability of a strong, continuous current passed through the brain and upper part of the cord to kill; but that the mode of death is quite different from that which takes place when the heart lies in the conducting path and is traversed by the current. In the former the lethal effect is plainly the result of asphyxia due to a respiratory inhibition, while in the latter the lethal result, even from moderate currents continued for a short period, is due to the permanent stoppage of the heart's co-ordinated action, the central nervous system dying from anæmia.

Cunningham's experiments, in common with all others in which these points have been observed, show that a greater amperage is necessary to produce death when the current traverses the supreme nerve centres than when it traverses the heart. In his experiments, the relations were 1.1 to 1.6 in the former as against 0.3 to 0.65 ampere in the latter instance. His conclusions are embodied in the following summary:

"1. Industrial electric currents which traverse the whole body transversely or longitudinally in sufficient intensity kill because fibrillar contraction of the heart is produced and not, as has been hitherto surmised, by producing a total paralysis of that organ or killing it outright.

"2. Such currents neither kill the central nervous system outright nor paralyze it instantaneously. Death of the nervous system from such currents is due to the total anæmia following a sudden arrest of the circulation.

"3. In rare instances, when an electric current traverses only the cerebro-cervical portion of the nervous system in considerable intensity and for a considerable length of time, it may kill by asphyxia consequent to more or less complete inhibition of the respiratory movements, which occurs chiefly during the passage of the current. No existing facts warrant the conclusion that the medullary respiratory centre is paralyzed or killed in such conditions.

"4. Industrial currents are practically non-lethal to frogs and turtles, as the condition of fibrillation quickly and spontaneously disappears from their hearts after the current has ceased to pass. Such animals, of course, can be killed by the very prolonged application of a current of moderate intensity, or by one of enormous voltage and large intensity.

"5. Strong electrical currents applied to the surface of the skin affect the heart in the same manner as currents of less strength do when they are applied directly to the exposed heart.

"6. It may be possible for an electric current of enormous intensity and electromotive force to produce instantaneous death either by its disruptive action or by producing an instantaneous heat coagulation of the cellular constituents of the body. Industrial currents do not kill instantly, although as a result of their action death rapidly occurs. The experience of individuals who have recovered from severe electric shock indicates that such a mode of death is not a painful one.

"7. Spontaneous recovery of the dog's heart from fibrillation produced by strong currents is rare. Spontaneous recovery of the dog's heart from fibrillation and restoration of the arrested circulation after the external application of a strong current for two or three seconds appears not to exist.

"8. Artificial recovery of the fibrillating heart of the dog, with restoration of the circulation and recovery of the nervous system, can be accomplished by the method described in this paper, provided the duration of the shock is short and the procedure is begun immediately after the cessation of the current."

Clinical Manifestations in Electric Shock.—As the result of electric shock in both animals and man there are distinguished five stages of effects: Muscular contractions; clonic convulsions; tonic convulsions with momentary stoppage of respiration; general inhibition of respiration and of the nervous system, but without convulsion; and lastly complete stoppage of the heart's action.

When a strong current is brought to bear upon the subject there is a strong tetanic contraction. Sometimes, not always, when the circuit is broken, a deep respiration takes place followed by an expiratory cry. In the tabulated list of accidents it is noticed in but one instance (Case 4).

Cunningham describes the clinical manifestations in a case of electric shock of which he was a witness. An electrician who was on the point of removing a defective brush from the motor of a trolley car was partially beneath the car, with his right hand on the brush, when he inadvertently rested his left hand on a live rail; immediately his muscles became tetanic and he was thrown backward in an instant, thus severing his connections with the live contacts. Syncope occurred in a few moments, and during its continuance the respirations were at first rather rapid, later possibly a little slower and shallower than normal. His pulse was very soft, rapid, and slightly irregular, but soon consciousness returned. He then vomited once and was able to get up by himself, though he complained of feeling extremely weak. The next morning he stated that the prostration had persisted for about two hours and then disappeared, leaving him as well as ever. The pressure of the current in this instance was 500 volts, but, by reason of the position and nature of the contact (hand-to-hand, dry skin), the resistance was so great as to minimize the current so that probably not more than a small fraction of an ampere passed through him. These effects, Cunningham concludes, are produced as follows: As the accidental contact with the live wires, rails, brushes, etc., is made, more or less pronounced general muscular contractions occur. Respiration may be inhibited after a deep inspiration and expiration, but is quickly resumed. From the moment the shock begins there is temporary inhibition of the heart's action accompanied by a fall in the blood pressure. After exposure to a non-lethal current of brief duration, both normal heart beat and blood pressure are soon recovered. Consecutive to diminution of the blood pressure and disturbance of the cerebral circulation, more or less syncope frequently occurs, but this is gradually recovered from and normal circulation is re-established. When a large portion of the current traverses the brain (head and back of neck contact, for example) the underlying sensory-motor centres of the brain may be stimulated to such a degree that in a few moments one or more general convulsions, quite similar in many respects to an epileptic fit, may be produced. If syncope had not been induced previously by the cerebral anæmia resulting from the lowering of the blood pressure and disturbed heart action, the onset of a general convulsion in all probability would be accompanied by complete loss of consciousness. Loss of consciousness is not confined to fatal cases, and the longer it continues the less danger there is to life. It rarely persists longer than a few minutes, but may be followed by headache for several days—possibly by vertigo. In Cases Nos. 2 and 8 (see tabulated list of accidents) loss of consciousness was prolonged, and in No. 8 not completely recovered from for twenty-four hours. It is very rare that sensory or motor paralysis appears as the result of an electric shock. In Case No. 2 (see tabulated list of accidents), there was slight sensory disturbance; in Case 10 motor paralysis, and in Case 21 both sensory and motor paralysis. Convulsions sometimes occur and seem to bear a relation to the contacts. If the energy is expended upon the supreme centres they are more apt to appear. In Case No. 2 (tabulated list of accidents), the man was blind for forty-five minutes, delirious for several hours, and for several hours unable to speak. In No. 7 the pupils were observed to be dilated —a condition often noted.

In most cases no permanent ill effect appears to follow an electric shock. On the other hand, Case 10 (tabulated references) claimed to "feel better in general health" than before. This is not an unreasonable statement in view of the physiological action of an electric current in a therapeutic dose.

The following case, however, suggests the possibility of the development of traumatic neuroses from electric shock in common with other forms of injury: A workman while at work on an electric transformer, standing on a perfectly dry floor, received a shock of 3,000 volts, with 100 interruptions per second. He lost consciousness for twenty or thirty minutes, and then he was able to get up and walk to the carriage. For about two months he was treated for burns which he had received, and recovered sufficiently to resume his work. Soon afterward he developed a neurosis associated with hysteria and neurasthenia. He presented a concentric narrowing of the field of vision, clonus of the patella, irregularity of the pulse, increased reflex action and muscular irritability, vaso-motor disturbances and weakness of the extremities. In other words, this was a typical case of traumatic neurosis developing several months after the injury.

The patient finally recovered under bromides, massage, and electricity.*

Post-mortem Findings.—The post-mortem findings in death from electricity present fairly uniform conditions:

1. Rigor mortis is always quickly established. Tatum found it generally established in the second or third hour, but it occurred in fifty minutes in one instance. It was established in every instance without any relation that could be traced to the strength of the current. It was never absent where it was sought for, and presented nothing noteworthy in its character save promptness of appearance.

2. The extent of injury to the skin in electrical injuries and fatalities varies greatly. The points of penetration of the current are always evidenced by burns of greater or less degree. The place of exit is less frequently marked by burning than is that of entrance. The evidences of burning may be very well marked or they may be, on the contrary, very slight; and they are by no means proportional to the gravity of the accident,—depending as they do upon the condition of the skin, whether moist or dry, as well as upon the nature and duration of the contacts. In Case No. 6 (see tabulated list of accidents) —pressure not given, death instantaneous—a small blister only was found on the left index finger, while in Case 14 (contact with a 2,000-volt continuous current) the thumb of the right hand with a portion of the joint was burned off. Intense cutaneous congestion and patches of ecchymosis are often found (see Cases 5 and 6, tabulated references).

3. As to the heart, Tatum found that if the body was opened immediately after a sudden death the heart was always found to be in a lax condition, both ventricles distended with blood, and both auricles pulsating rhythmically. If the examination was delayed a quarter of an hour or more, or if it followed a less rapid death, the left ventricle was sometimes found empty and more or less firmly contracted. The observations of other experimenters point to practically the same condition of the heart,—that, namely, which follows death by apnœa.

4. Blood-vessels and blood: The arteries are often contracted to their smallest calibre and the blood is crowded into the very large veins of the trunk and head. There is sometimes rupture of the blood-vessels (see Case 11, tabulated references, and also twenty-fourth electrocution). Tatum found the blood in the arteries bright red if the body was opened at the end of a minute or so after death; but if the examination was delayed for a few minutes the blood was quite black. On free exposure to the air it turned scarlet as promptly as other venous blood and clotted quite normally. There is an absence of hæmoglobin from the blood in death due to electricity, as in apnœa. Great fluidity of the blood and absence of clots are marked features in death from industrial currents. Cases 6, 7, and 15 of the tabulated references are excellent illustrations of this post-mortem condition.

5. Viscera: The viscera are frequently found congested and sometimes engorged with blood (see Cases 7 and 15 of the tabulated references).

6. The nervous system does not present any gross lesions, nor have any microscopic evidences of changed conditions been found. That molecular changes which are not determinable by present methods may be found is very possible. On the other hand, there may be gross disorganization of the brain, with destruction of the peripheral cortex and intracranial effusion of blood. The latter, with rupture of blood-vessels, was a marked feature in the twenty-fourth electrocution in the State of New York. Slight hemorrhages in the walls of the fourth ventricle and in the meningeal coverings are not rare.

Prévost and Battelli never found intracranial hemorrhage when elevation of the temperature had been avoided, although there was sometimes hyperæmia of the meninges. In Case No. 5, of the tabulated references, there was hemorrhage into the common sheath of the carotid and the vagus nerve on both sides of the neck, and there were also symmetrical hemorrhages along the spinal cord.

The post-mortem findings in Nos. 5, 6, 7, 11, and 14 of the tabulated list of accidents—in which cases the examination was made at times varying from ten hours to three days after the occurrence of the accident—may be summarized as follows:—In every instance there were marked rigor mortis and great cutaneous congestion, with patches of ecchymosis; the heart was uncontracted and empty; the blood was markedly fluid and would not coagulate; there was but little blood in the large blood-vessels; the viscera were engorged with blood. In some instances there were ruptures of small blood-vessels, and burns of greater or less severity were found on different parts of the body. In Case No. 7, the vessels of the scalp, meninges, and brain were congested and full of liquid blood, and so also were the lateral sinuses. This accident from a 2,000-volt current seems to have affected the brain instantaneously, as the subject fell as in a fit; but the heart and respiration did not stop until five minutes later.

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* Brustein, S. A.: "On the Action of the Electric Current of High Tension (Pressure) on the Human Body." Vratch, April 21st, 1901, vol. xxii., No. 16.

Is Death Instantaneous and Painless?—The conclusions of Houston and Kennelly, whose experiments were undertaken to answer the above question, are as follows:

"1. That the passage of a sufficiently powerful alternating current through the body of an animal is followed by instantaneous, painless, and absolute death.

"2. That consequently where electrocution is properly carried out there is not even a remote possibility of subsequent resuscitation of the criminal.

"3. That in case of accidental contact, where the current passing is not excessive, it is quite possible that death may be apparent only, and that the method of artificial respiration suggested by Dr. D'Arsonval should invariably be followed."

In the analysis which the writer has made of all the data at her command, and in the evidence furnished by experiments upon animals, by accidental contacts of man with industrial currents, or by electrocutions, there is nothing which contradicts the conclusions just stated. There may be a difference of opinion as to what is meant by instantaneous death, although the experiments of these authorities showed immediate and absolute arrest of the cardiac function.

So far as the ego is concerned, death is no doubt instantaneous, but from the physiological point of view this need not necessarily be true. Physiological death is not, judging from the evidence in many instances, established until some time after conscious death. The results of Cunningham's experiments show that all the tissues of the body, the nervous system and the heart included, are not killed instantaneously, and that the respiratory centre continues to act more or less perfectly for some moments after the cessation of a lethal current. On the other hand, in the experiments of Houston and Kennelly, the dogs, with the exception of the one in which the current was passed through the head, died instantly —*i.e.*, no cardiac movements nor respiratory effort occurred after the application of the current.

From an analysis of nineteen cases the subject of severe but non-lethal shocks, Cunningham concluded that there was ample time before loss of consciousness for the recipient of the shock to become aware that he was or had been in contact with an electric current. Every one of the nineteen individuals experienced some sort of sensation (for description of sensations and conditions produced from an electric shock experienced by a physician, see Case 21, tabulated references of accidents) before consciousness was lost,—a sensation which was described by them as similar to that produced by catching hold of the electrodes of a small but strong medical induction coil. Usually a sensation of tremendous pressure is felt across the chest. It does not follow, however, that a lethal would be accompanied by as much sensation as a non-lethal shock. Indeed, to the writer's mind, the question of physical pain from electrocution is not only not proven by the evidence, but disproved. "With the nearly instantaneous extinction of the cerebral circulation, such a rapid and complete cessation of the functions of the cerebral cortex occurs that no time remains for sensations other than those of an electric current to be felt before the cerebral perceptive nerve centres have ceased to act." The suffering must be the mental anguish and consequently of the same character as that experienced by the condemned criminal, no matter how death is to be brought about.

When the enormous pressures used in the industries are considered, it does not seem difficult to believe that death may be instantaneous, even from accidental contact. Continuous currents of 10 kilo-volts are sometimes used in series arc lighting—ordinarily only 3 kilo-volts are used. The ordinary limit, however, in the case of a continuous current is but 600 volts. In the case of alternating currents the pressures are very much greater and go up to 40 or even 60 kilo-volts in the long-distance transmission of power.

In the writer's opinion, based upon an analysis of experimental work, accidents from industrial currents and electrocutions, as well as upon the experience of those who have suffered from electric shocks of varying severity, there seems to be no good reason for doubting that death from an electric current, so far as consciousness is concerned, is instantaneous and unaccompanied by any pain save the possible cerebral perception of an electric shock.

As to Spontaneity of Recovery.—Many instances of spontaneous recovery after accidental contact with industrial currents of high pressure are a matter of record. In these cases, as has been pointed out, but little—possibly none—of the current has traversed the heart, by reason of the position and the nature of the contacts. Therefore, the co-ordinate contractions of the heart are not stopped. Or if the current has traversed the heart, it may not, for some reason inherent in the individual, as suggested by Prévost and Battelli, have established well-defined ventricular tremulations; and consequently, in such a case, after the flow of the current has ceased, recovery takes place. Whether the recovery is spontaneous or is influenced by artificial respiration, depends no doubt upon the degree of inhibition of the respiratory centre and the consequent asphyxia. If the nervous system has suffered profoundly before the current is stopped, spontaneous recovery is extremely doubtful, just as it is in profound asphyxia from other causes. In some instances, apparent death from lightning is but a condition of suspended animation, and it is, therefore, well always to practise artificial respiration in all cases of lightning stroke. But where the electrical energy has expended itself in producing a disruptive action, or mechanical lesions of vital organs, efforts of resuscitation are useless.

In Case No. 10, of the tabulated references, recovery was spontaneous; in Nos. 3 and 8, artificial respiration was practised; while in No. 2, morphine, brandy, and sinapisms to the præcordium were used. It is possible that spontaneous recovery might have taken place in all four instances.

On the other hand, when a strong current has passed through the heart—Cunningham places it at from 1 to 8 amperes—the organ goes at once into a condition of fibrillar contraction. He considers it most improbable that, after the brief passage of such a strong current, spontaneous recovery of the highly organized heart, with complete restoration of the extinguished circulation, would ever take place. As a matter of fact, he concludes, from his experiments upon fibrillating excised dogs' hearts (with artificial perfusion of blood), that such recovery would never take place spontaneously in the brief interval which exists before the vitality of the central nervous system has become so reduced as to be incapable of recovery. After the arterial blood pressure has disappeared, "I have never seen," says Cunningham, "a single instance, in a series of more than thirty experiments on dogs, in which spontaneous recovery of the co-ordinated contractions of the heart, with restoration of the general circulation, occurred. The simpler the heart the more rapid the recovery; therefore, the spontaneous recovery in frogs after a severe shock."

In electrocutions, Cunningham believes that if the autopsy is deferred for one hour and no signs of recovery are then manifested by the executed criminal, one may rest assured that recovery could not take place either spontaneously or by artificial means. He points out, however, that the excised heart would probably be made to beat again co-ordinately if it were perfused with blood.

Resuscitation.—As to resuscitation after electric shock, an analysis of the work of the different experimenters instanced in this paper points very clearly to the inefficiency of artificial respiration when there has been a purposed application of a lethal current; and an analysis of the accidents occurring from electric currents points to the same conclusion.

D'Arsonval, in 1887, and later in 1894, voiced the opinion that after an electric shock the individual should be treated by means of artificial respiration, as in the case of the drowned, "since the condition after the shock is one of suspended animation, in which the respiratory function is suspended."

In the light of the experiments quoted in this paper, such a procedure can be regarded only as unphysiological and ineffective. In those cases in which the heart happens not to be in the direct conducting path of the electrical current (as in brain and spinal-cord contacts), and consequently feels the influence of the latter in a diminished degree, it is quite possible that the establishment of artificial respiration may be found useful. In accidents in which there is but a momentary contact with a current of high pressure artificial respiration is always indicated. But when the current has exerted its power mainly upon the heart and the latter has ceased to beat, artificial respiration will do no harm, but we can scarcely expect that it will do any good. Finally, in those cases in which there has been an actual mechanical and disruptive action, death is absolute and artificial respiration valueless.

It has been shown that after a brief application of an electric current to the exposed heart of a dog, a brief period of fibrillation may be followed by the reappearance of a few co-ordinated heart beats (Herbst and McWilliams). "Should this occur," says Cunningham, "before the general blood pressure has become greatly diminished, it is possible that the disturbed circulation might be restored. Once, however, it has fallen to zero the right heart becomes so overdistended with venous blood, which may coagulate in a few moments, that even though one or more feeble, co-ordinated beats occur, the overfilled right heart cannot empty itself with sufficient rapidity through the lungs so that the left ventricle can produce enough pressure in the aorta for the necessary blood to be forced through the coronary circulation rapidly enough for the spontaneously restored co-ordinate contractions to be maintained."

In those cases in which artificial respiration is indicated, inhibition of the respiratory centre (Laborde's method), which Laborde called the physiological treatment of death (*i.e.*, rhythmic traction of the tongue), should be practised.

When the action of the electrical current has been upon the heart, the indication is to restore the circulation—not only of the nervous system, but also of the heart—as quickly as possible, in order that the latter may quickly recover its co-ordinated contractions. There is but one way in which this may possibly be accomplished, viz., by the establishment of a temporary circulation of a fluid which will feed the heart and nervous system until the former has sufficiently recovered to perform its function. "Of all the various fluids recommended for intravascular injection, the defibrinated blood from another animal of the same species is the only one capable of maintaining the circulation. The mere arterial injection of warm, defibrinated blood would not answer, for the injected blood, after passing through the capillaries, accumulates in the venous system and in the distended right heart until finally the veins rupture or the general vascular pressure equals the pressure of the blood being injected. The overdistention of the heart prevents the re-establishment of the coronary circulation, an element of great importance in establishing the co-ordinated heart beat.

"This enormous increase in the pressure could be prevented only by the establishment of an outlet in the right ventricle for the injected defibrinated blood. With such an outlet the oxygenated blood would circulate through the coronary arteries and the nervous system, but naturally there would be no pulmonary circulation. Under these circumstances artificial respiration would be of no avail, save possibly to assist the outflow from the heart."

Owing to these very serious obstacles the matter of resuscitating the heart's action by perfusion of defibrinated blood becomes at once absolutely impracticable. The solution of the problem as a mere laboratory experiment is a totally different matter.*

The observation of the fact that the employment of oscillatory currents of high potential favors the recovery of a fibrillating dog's heart, and of the results obtained by the use of such currents in therapeutic work, suggests the possibility that a similarly favorable effect may be produced in the human being in cases in which the heart has not been too profoundly affected. Experimental work in this direction could not fail to be of value, no matter what might be the conclusion reached. Further experimental researches into the mechanism of death are also desirable. However, if we are to obtain further knowledge as to when an attempt at resuscitation is likely to prove successful, we must not only extend our experimental researches, but we must also observe with greater care and with more scientific accuracy the phenomena resulting from accidental contact with industrial currents, and we must study more closely the post-mortem conditions. It is also desirable that accurate observations and records should be made of all the conditions of the conducting circuit, of the character and pressure of the current, of the current strength or amperes, of the position and nature of the contacts, and also of the duration of the contact. Such accumulated evidence should be of value in establishing the fact of death and determining its mechanism, or in indicating, in cases of apparent death, the phenomena which warrant the hope that efforts at resuscitation will prove successful.

The following table of accidents from electric currents has been largely made up from cases described in medical and electrical journals. In all accounts of accidents, whether mortal or not, the data given have been found to be very meagre, and the table, though very incomplete, is as full and exact as the data furnished would admit of. There is also in both medical and electrical literature a striking dearth of detailed cases and even of any mention of accidents, which leads to the assumption that they are comparatively rare.

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* For a detailed account of the apparatus to be used in the laboratory for the recovery of animals the subject of experiment, see Cunningham's article, New York Medical Journal, October 21st, 28th, 1899.

Reference.	Circumstances.	Current.	Symptoms.	Result.	Post-mortem findings.	Treatment.
1. R. W. Pope: New York *Sun*, October 14th, 1895.	Accidental contact with wire in cellar of residence; heard to fall; found dead.	2,100 volts, alternating from converter; leakage possible.	Not given; found dead.	Death	Deep ragged scratch on right hand and electrical burn; other minor burns.	
2. New York *Sun*, January 22d, 1896.	Faulty connections of wires. Current passed direct from dynamo to switch, omitting transformer; switch handle grasped.	2,000 volts, alternating.	Felt smarting pain in palm of right hand; no other pain for some minutes, then dizzy and fainted; soon recovered. Later spasms of pain in injured arm, running across breast to heart, which felt as if grasped in a vise. Red marks, shape and size of banana, under each ear; sensitive. On left arm, midway between shoulder and elbow, two irregular black and blue marks close together, one by one-half inch. Around these flesh inflamed and puffed up. Spasms of pain, forty at intervals of a few minutes; entire left side numb; blind forty-five minutes; delirious some hours; later, for several hours, unable to speak.	Recovery		Morphine, brandy, sinapisms to præcordium.
3. D'Arsonval: Comptes rendus de l'Acad. des Sciences, 1894, p. 1139.	Man sat astride of bar connecting wires, telephone wire in hand which touched another conductor.	4,500 volts, 750 ma., frequency 55 periods per second, duration several minutes.	Apparent death. Lungs began to act almost at once after artificial respiration began; burn on right hand and buttock.	Recovery		Artificial respiration. Method of Laborde. After two hours, spoke.
4. Cardew: London *Electrical Review*, March 15th, 1895.	Rubbing dust off high-pressure "terminal board"; neglect of rubber gloves.	2,000 volts, alternating.	Uttered loud cry; lost consciousness; remained standing leaning against the terminals.	Death	Not given	Artificial respiration.
5. Kratter: London *Lancet*, August 31st, 1895.	Workman stringing telegraph wires.	Not given	Not given	Death	Twenty-one hours after death. Ruptured blister on left forefinger. Marked rigor mortis; intense ecchymosis on dependent parts. Hypervenosity of blood; venous engorgement of lungs; blood extravasated into common sheath of carotid and vagus nerves on both sides. Symmetrical hemorrhages along spinal cord.	Not given.
6. Shield and Delphine: *Brit. Medical Jour.*, 1885, vol. i., p. 531.	Manipulation of electrical machine, accidental putting self in circuit.	Not given	Not given. No alteration perceptible in texture of clothes nor in metallic substances on the person.	Death	Forty hours after death. Rigor mortis marked; great cutaneous congestion; on left index finger small blister; appearance of burn, but no redness around it; no charred smell; muscles of thorax firm and resistant to knife; internal viscera healthy; extreme fluidity of blood; heart uncontracted; fibres under microscope normal: microscopic examination of sections of region of blister showed marked differences from common burn. (Described in detail.)	Not given.
7. Clowes: London *Lancet*, December 17th, 1892.	Making connections with house for street current.	2,000 volts, alternating, 10,000 per minute, 166+ per second.	Fell to one side as in a fit; five minutes after, heart and respiration were stopped; surface congested; pupils dilated; features not distorted; smell like gas; palm and first two fingers of left hand burned; fingers flexed; clothing not burned.	Death	Three days after death. Rigor mortis marked; decomposition not advanced; burns as described, deep and carbonized; epidermis of palmar surface burned black and separated; dorsal surface, epidermis destroyed in small circular spot; ecchymosis and swelling on right frontal eminence; vessels of scalp, meninges, brain, and brain substance congested and full of liquid blood; lateral sinuses full of blood; mucous membranes, larynx, trachea, and bronchi congested; lungs loaded with dark blood; heart not contracted, but cavities completely empty; deficiency of blood in large vessels; liver congested and dark red; spleen large and engorged with blood; kidneys large and congested; complete fluidity and dark color of blood; not a clot found in body.	Artificial respiration for one hour, no response; Strychnine hypodermically. Faradic current to præcordium.

8. New York *Herald*, May 31st, 1901.	Boy nine years old, caught hold of electric light wire passing over roof; insulation insufficient.	10,000 volts	Immediately swung off into air; smoke arising from the wire at point of contact. Boy's hold not loosened until hands were pounded; body dropped apparently lifeless.	Recovery..	....	After boy supposed to be dead, artificial respiration practised; semi-consciousness produced, continuing twenty-four hours or more (not definitely stated).
9. Kolben: *Electrical World and Engineer*, March 17th, 1900, vol. xxxv., No. 11, p. 411. *Elek. Zeit.*, February 15th, 1900.	Workman in potash and alcohol plant stood on iron tank covered with soda lye of good conductivity; boots wrapped with rags of twilled linen; drunkard.	95 or 96 volts, alternating.	....	Death.		
10. W. S. Hedley: London *Lancet*, December 5th, 1896.	Casually placed hand on metal corner of ammeter and, turning, placed other hand on iron pillar. Ammeter case in accidental metallic contact with light leads and return wire was earthed by contact with iron post.	2,500 volts, alternating.	Found himself standing on floor, forearm drawn up to chest, hands clenched; from above elbow downward described feeling of pulsation and violent beating in synchronism with alternations (83 periods per second); power of movement below elbow lost, but arm at shoulder could be moved; pulsation soon became less violent and motor power returned successively in the muscles of forearm, wrist, and fingers. In three minutes completely restored. No sensation of burning at the time, but in ten minutes hands became painful and examination revealed burn on tip of left middle and ring fingers, with scarred line across lower portion of palm. Since accident, claims to feel better in general health.	Recovery.		
11. London *Electrical Review*, February 23d, 1900.	Assistant in electric light station accidentally put hand on spring on switch-board. No insulation on floor.	3,000 volts, alternating.	Instantaneous death..........................	Death	Cauterized wound on knuckle of left forefinger. Heart empty of blood; several small blood vessels shattered.	
12. London *Electrical Review*, June 15th, 1900.	Victim found dead with wire grasped in left hand, which was used to draw arc lamp up and down; leakage to wire.	700 volts, direct current.	Instantaneous death..........................	Death.		
13. London *Electrical Review*, August 6th, 1897.	Employee at electric light station.	Not given	Instantaneous death..........................	Death	Not stated....................................	Artificial respiration one hour.
14. London *Electrical Review*, June 3d, 1898.	Employee at electric light station, switched off transformer without gloves.	2,000 volts, high-pressure, continuous current.	Instantaneous death..........................	Death	Thumb of right hand with portion of joint burned off; tracing up arm where electricity ran; skin peeled off.	
15. London *Electrical Review*, September 2d, 1898. From *Cape Times*, August 8th, 1898.	Wireman working in transformer chamber caught hold of fuse handle; was removing some temporary electrical apparatus which had been used at a ball at Government House; rubber mat and rubber gloves within reach but not used.	1,500 volts	Spoke after shock but died immediately	Death	Left heart empty; blood did not coagulate. Rigor mortis strong after nineteen hours. Brain and other organs congested.	None.
16. London *Electrical Review*, October 21st, 1898.	Electric wireman fell across terminals of one of the machines in electric supply station; was crossing wires leading to a switch-board.	1,000 volts	Found dead in semi-reclining position.........	Death	Not given.	
17. London *Electrical Review*, July 24th, 1896.	Sub-foreman at electric light station; neglect of rubber gloves in making a connection.	Not stated	Instantaneous death..........................	Death	Burn between thumb and index finger of left hand.	Artificial respiration. Time not given.
18. London *Electrical Review*, January 6th, 1899.	Workman making temporary point on high-pressure cable.	2,000 volts	....	Death	....	Artificial respiration.

Reference.	Circumstances.	Current.	Symptoms.	Result.	Post-mortem findings.	Treatment.
19. London *Electrical Review*, January 27th, 1899.	Accidental contact with wires of arc-lamp circuit.	4,000 to 5,000 volts.	Fell immediately but rose, took three or four steps, and sank unconscious.	Death	....	Artificial respiration. Died on removal to place of shelter. Time not stated.
20. London *Electrical Review*, September 20th, 1898. *l'Industrie Electrique*.	A beam fell upon wires carrying them down upon workman, who was killed. The other workmen who went to his assistance were killed.	2,400 volts, alternating current.	Instantaneous death in the three cases	Death.		
21. *Revue Scientifique*, May 18th, 1901. (Variétiés.) ("Souvenirs d'un Electrocuté.")	Grasped two large electrodes; current passed two or three seconds before turned off.	Secondary current from a Ruhmkorff coil, excited by alternating current, 110 volts, 42 periods per second, about 20 ma., primary current 50 amperes.	No burn. Thrown to the ground by general muscular tetanus; could not cry out; lost sensation of upper limbs and trunk; perturbation of vertical and color sense; unconscious a few seconds; no pain. On trying to move arms and hands found them paralyzed. Hyperæsthesia to cold; loss of tactile sensibility and muscular sense; hyperæmia of hands and forearms. In three to four minutes arms recovered mobility; fifteen minutes hands the same; some hours after, interossei recovered. Same time, three to fifteen minutes, tactile sense and muscular sense recovered. Heat sense returned to normal half an hour later. At this time on trying to walk, out of breath. One hour and a half after, tachycardia, arrhythmia, continuing until next day; stopped suddenly. Lassitude lasted thirty-six hours.	Recovery.		

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ELECTROTHERAPEUTICS.—The knowledge of the therapeutic applications of electricity presupposes a thorough familiarity with the main principles of electrical effects upon tissues and organs, and also with the proper dosage of every form of electricity in every given case; it also presupposes a familiarity with the different forms of batteries used for therapeutic purposes. A series of observations shows that the blood-vessels contract and dilate when they are under the influence of an electrical current and that the normal irritability of nerves is changed when a current passes through them. This last phenomenon is called electrotonus. It has been observed that the anode of the galvanic current applied to a nerve diminishes its irritability, while the cathode increases it. The law of electrotonus is equally true of sensory and of motor nerves. Electrical stimulation of a motor nerve produces a contraction of the muscle innervated by the nerve and its branches. A current passing through a sensory nerve will produce pain, while a current influencing a mixed nerve will produce both effects—motor and sensory. Electricity causes muscles not only to contract but also to undergo changes of a trophic character.

Apart from the purely physiological influence upon blood-vessels, nerves, and muscles, electricity shows its chemical effects by means of cataphoresis and electrolysis. By cataphoresis we understand a phenomenon which partakes of the nature of osmosis and which is brought into existence by the action of a galvanic current upon organic tissues. Thus, for example, medicinal substances, as mercury, cocaine, chloroform, etc., can be transferred into the tissues when an electrical current passes through the skin to which the drugs are applied. By electrolysis we understand a splitting up of chemical compounds into their component elements, the acid element being set free at the positive, the alkaline element at the negative pole. In living tissues an acid, dry eschar is formed under the positive pole, an alkaline, moist slough under the negative pole.

FORMS OF ELECTRICITY FOR THERAPEUTIC PURPOSES.—The forms of electricity used in therapeutics are: static, galvanic, and faradic.

The application of *Static Electricity* to the body for therapeutic purposes is known as Franklinization. This is the form of electricity which is developed by rubbing certain bodies, and which has the property of spreading over the electrical conductors (for example, metals) and of remaining there. The terminal portions of these bodies have more tension than the middle portions; at the sharp ends the tension is greatest. One distinguishes two sorts of this electricity—positive and negative. By contact with electrical bodies the non electrical bodies become electrified. Also at a distance the electrical bodies have an influence over the non-electrical bodies (induction). If a non-electrical body is brought into close proximity with the negative pole, the body in question will be found to have assumed the character of a positive pole. For therapeutic purposes one can use direct contact with either the positive or the negative pole. Several methods are employed in Franklinization: (*a*) *Insulation.* The patient is placed upon an insulator and is connected with one pole of the static machine by a chain. The free end of the other pole (also a chain) rests upon the floor. The machine is put in rapid motion. The patient is charged with static electricity. (*b*) *Sparks.* When a piece of metal attached to the free end of the chain is brought close to the patient's body, insulated as before, sparks will be obtained from it. Sparks are powerful means of exciting deep organs, as well as the skin, and the procedure is attended with pain. (*c*) *Breeze.* If instead of a ball electrode a pointed electrode is used, a sensation as of a spray will be experienced; this is called a breeze. (*d*) *Induced static current.* In this case a pair of sponge electrodes are attached to two Leyden jars, which are suspended from the poles of the machine. Before applying the sponge electrodes to the body, the poles should be approached to each other. An induced static current is thus obtained. One of the best electrodes for this purpose was devised by W. J. Morton, who named it a pistol electrode. Ranney's device (Fig. 1834) is a decided improvement for use in applying induced static electricity. Other electrodes used with static machines are: a plate for the head, in the form of a crown, and a button-shaped electrode.

Galvanic currents are used in therapeutics for general and for local applications. The different methods of employing galvanic currents are termed *central galvanization, local galvanization, general galvanization*, and that by means of the *galvanic bath.* In central galvanization one large negative electrode is placed over the epigastrium and the positive electrode over the head, along the spine, or against the trunk. Each *séance* should last not more than fifteen minutes. In local galvanization the rules of application are the same; the cathode should be placed on some indifferent spot, as the sternum or the neck, and the anode on the diseased spot. In general galvanization the patient is seated on a large negative electrode, well moistened, and the other electrode is applied first to the head, then to the neck, face, upper extremities, trunk, and lower extremities. As to galvanic baths we distinguish two varieties: *monopolar* and *bipolar.* In monopolar galvanic baths the cathode is connected with the water, while the anode is either connected with a tube lying over the bathtub, which the patient will hold in his hands, or with a large plate which is put on the patient's back or on some indifferent part of the body (sternum, neck). The bath is called cathodal, when the water is connected with the cathode, and vice versa. A bipolar galvanic bath consists of a bathtub, where both electrodes are connected with the water, and the patient is not in contact with either. The currents will pass through the body from one electrode to another. Each *séance* should last at the beginning about ten minutes. As to the strength of the current it may be permitted to reach 100 ma.

Faradic Electricity.—This form of electricity is used in therapeutics both in a general manner and as a local application. The utilization of general faradization is governed by the same rules as those given for general galvanization. The only point to be mentioned is that on account of our inability to measure exactly the strength of the current in a faradic battery we must guide ourselves by the sensory or motor effects. Local faradization which is used for stimulation of the skin, muscles, and deep structures, is obtained by using large sponge electrodes or dry brush electrodes. The method of application is exactly the same as that already mentioned. Special mention should be made of the combination of galvanic and faradic currents in one machine, but we do not as yet possess positive data as to the real value of farado-galvanization.

Therapeutic Effects of the Various Forms of Electricity.—*Static electricity* increases the blood pressure, accelerates the circulation, stimulates the function of secretory organs, and restores disturbed functions. Sparks and induced static electricity are indicated when a strong action is sought for. The advantage of Franklinization is that it can be applied through the clothing. *Faradic currents* have their effect upon muscular contractility and vaso-motor phenomena; this form of electricity is therefore indicated in effusions, which will be absorbed through the stimulation of the vascular system. In disorders of deep-seated organs faradism, by producing hyperæmia of the skin, will relieve congestion. *Galvanism* shows its effect in various ways. The vasomotor effect will be manifested in the variation of the calibre of the blood-vessels. As to the trophic effect of galvanism, there is no doubt that atrophies are favorably influenced by this form of electricity. The chemical effects of galvanism are manifested in cataphoresis and electrolysis (see above). A special practical application of galvanic currents is furnished in galvano-cauterization. This surgical procedure has an important advantage over other methods of accomplishing the same results. First, hemorrhage is a rare occurrence, and next, the cauterized surface presents a clean aseptic appearance. In operations in the nose, throat, or other cavities, it has a decided advantage over the thermo-cautery in the fact that it is applied cold and heated while applied to the diseased spot. This form of electrical application is indicated in ulcers, in angiomata, in fistulæ, where a stimulation of healthy granulations is desirable, in growths which are to be removed from the nose, pharynx, etc.

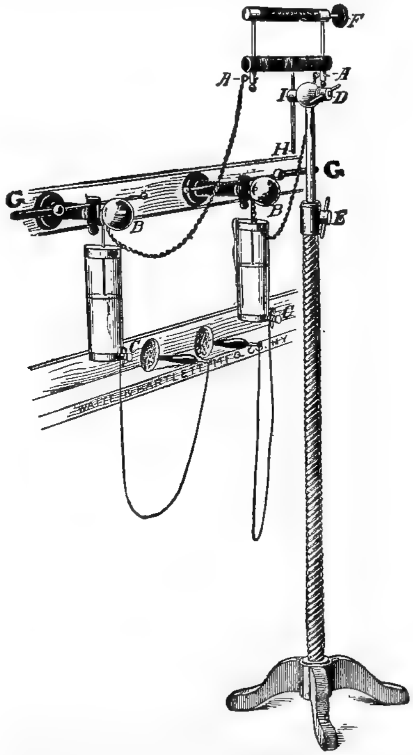

Fig. 1834.—Ranney's Device for Induced Current. To use this device, connect with short chains the poles of the static to binding posts *A A* on device. Use the current through well-moistened sponge-covered discs, the cord tips being connected to the binding posts attached to the Leyden jar supports. Press sponges firmly on part to be treated, and regulate strength by turning *F.*

Batteries Used in Electrotherapeutics.

The number of various batteries devised for electrotherapeutic purposes is considerable. They are made stationary and portable. The stationary *galvanic batteries* are the most satisfactory. The cells are put in a closet or cellar and connected with the switchboard by insulated wires. The cells present usually some modification of a Leclanché element. Otto Flemming of Philadelphia, Waite & Bartlett of New York, and the McIntosh Galvanic and Faradic Battery Company of Chicago make batteries which answer all therapeutic purposes except that of the galvano-cautery. They are all supplied with a galvanometer for measuring the strength of the current, an automatic interrupter or rheotome, a rheostat for increasing or decreasing the current, and a commutator for changing the poles of the currents.

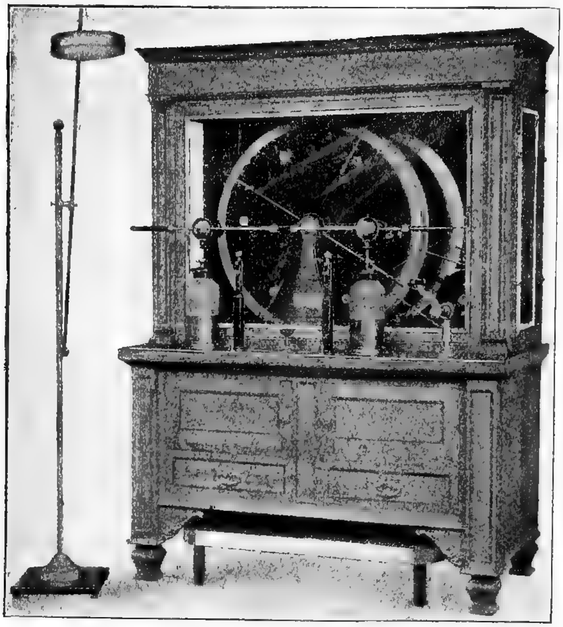

FIG. 1835.—Wagner Static Machine, with Four Revolving Mica Plates (diam. 28 in.) and Four Stationary Glass Plates (diam. 31 in.).

G. Betton Massey's movable table for hospital work should also be mentioned. The portable batteries, although supplied with all the accessories just mentioned, lack one desideratum, namely, the steadiness of action of the cells of stationary batteries. The Leclanché cells, or sulphate of copper cells, cannot be used on account of their size and weight, and bichromate cells, or bisulphate of mercury and chloride of silver cells, must take the place of the stationary cells. The writer has tested Flemming's bichromate portable battery, and, although it presents some inconvenience, it is at present the best form of portable battery. The Waite & Bartlett batteries are worthy of commendation. There are now on the market dry chloride of silver batteries which are very convenient.

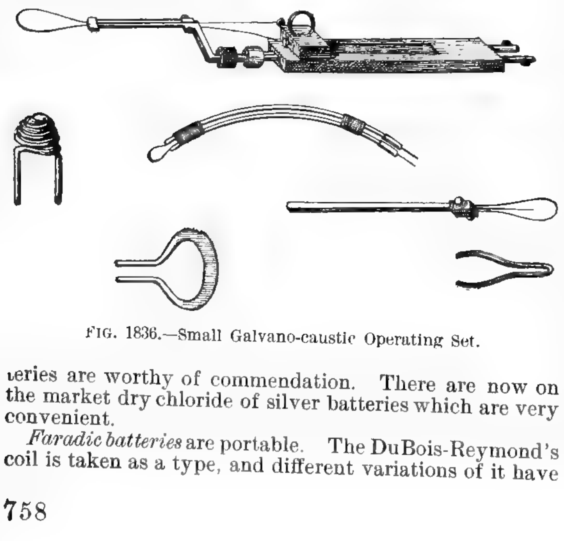

FIG. 1836.—Small Galvano-caustic Operating Set.

Faradic batteries are portable. The DuBois-Reymond's coil is taken as a type, and different variations of it have been introduced by different makers. Flemming, for example, has improved DuBois-Reymond's coil in a very advantageous way. Dry chloride of silver batteries in the hands of the writer have proven to be extremely satisfactory. *Static machines:* All the static machines devised for electrotherapeutic purposes have for basis Holtz's original machine. The McIntosh Battery Company of Chicago, Waite & Bartlett of New York, Queen & Co. of Philadelphia, make these machines with a high electromotive force. R. V. Wagner & Co., of Chicago, have lately devised a powerful static machine in which the use of mica plates (instead of glass) constitutes the principal feature. This new arrangement promises a very high speed. A machine constructed with mica plates 28 inches in diameter can be run at a speed of more than 2,000 revolutions per minute, whereas a machine with glass plates of corresponding size cannot be run faster than at a rate of 400 revolutions per minute; and, furthermore, as the generating capacity of the machine is in direct proportion to the speed at which it is run, a machine having two revolving mica plates has a much greater capacity than one having many times this number of glass plates (Fig. 1835).

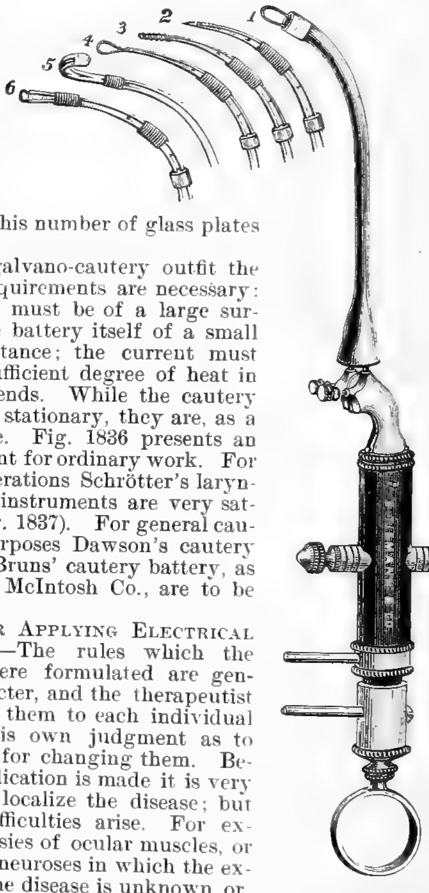

FIG. 1837.—Schrötter's Laryngeal Cautery Instruments.

As to a galvano-cautery outfit the following requirements are necessary: the elements must be of a large surface, and the battery itself of a small internal resistance; the current must produce a sufficient degree of heat in the cautery ends. While the cautery batteries are stationary, they are, as a rule, portable. Fig. 1836 presents an outfit sufficient for ordinary work. For laryngeal operations Schrötter's laryngeal cautery instruments are very satisfactory (Fig. 1837). For general cauterization purposes Dawson's cautery battery and Bruns' cautery battery, as made by the McIntosh Co., are to be commended.

RULES FOR APPLYING ELECTRICAL TREATMENT.—The rules which the writer has here formulated are general in character, and the therapeutist should adapt them to each individual case, using his own judgment as to the necessity for changing them. Before any application is made it is very important to localize the disease; but sometimes difficulties arise. For example, in palsies of ocular muscles, or in functional neuroses in which the exact place of the disease is unknown, or, finally, in progressive pathological processes of the central nervous system, in which the direct application of a current is an impossibility, we must content ourselves with symptomatic treatment—*i.e.*, we must apply the current to a place where, although it may be remote from the diseased focus, the most pronounced symptoms have been observed.

The next important consideration in electrotherapeutics is *the dosage of currents*. A strong galvanic current produces on the skin, and especially on the mucous membranes, painful, burning sensations, and is apt to injure the integument, so that sometimes after a single application an ulcer forms. The beginning of pain serves as a warning in regard to the strength of the current. Only a slight burning sensation is permissible. Faradic currents of stronger power produce only pain and redness of the skin; nevertheless, one should not use at the beginning a strong faradic current, because it is likely to frighten the patient and so to call forth resistance on his part. Galvanic currents of average strength, when applied to the head and neck, cause dizziness, flashes before the eyes, a peculiar taste in the tongue, nausea, tinnitus aurium, and in hysterical patients cramps and spells of all sorts. The same symptoms are sometimes observed even with milder currents when applied to the head and neck. They occur at each closure and opening of the current, especially when the increase or decrease of the strength of the current is produced abruptly, and not gradually. It is therefore necessary in applying electricity to that part of the body to use a rheostat and cautiously to move it forward or backward. The needle of the galvanometer will indicate whether the increase or decrease is rapid or not. The needle should not make abrupt movements, but slow and regular ones in the desired direction. It is advisable to put in as few elements as possible and to use up the whole rheostat or at least a large part of it. By this means it will be easier to avoid sudden changes in the strength of the current than if we employ many elements, as in the latter case the changes are more marked and sudden ones are more difficult to avoid in spite of the rheostat. In the employment of the latter, for either increasing or diminishing the strength of the current, it is strictly necessary to effect the change in a gradual manner, especially when we are making a polar application, *i.e.*, when we wish to obtain an anodal or a cathodal result. For example, in neuralgias we use the anode of the galvanic current in order to diminish or allay pain. In this case we must be particularly careful to increase the strength of the current, by means of the rheostat, very gradually. It is equally important not to reverse the current while it is closed, neither must we close or open it suddenly. It is therefore a good plan to instruct the patient not to remove the electrodes before the séance of treatment is terminated. In such cases one electrode should be provided with an interrupter, by means of which the closure and opening of the current can be effected in a gradual manner. For therapeutic purposes the electrodes should be first applied to the desired places, and only afterward should the current be turned on very gradually. In terminating a séance it is well first to remove the current (by a slow turning back of the handle of the rheostat), then next to disconnect the elements, and last of all to remove the electrodes.

If direct effects on muscles and nerve trunks are desired, one must moisten the electrodes *thoroughly*, because the resistance of the skin will thereby be diminished. Dry, especially metallic electrodes (brushes, etc.) exert a direct effect on the skin, and only an indirect one (through reflex action) on the central nervous system and the circulatory apparatus. They are especially used for faradic applications. For galvanic currents metallic electrodes are not advisable because of their injurious effect upon the skin. It is desirable, therefore, when galvanic currents are used, that the electrodes should be well covered in order that the patient's skin may not come in contact with their metallic parts.

In recent cases electrical applications should be made daily; in old cases every other day. When the applications are made less frequently they produce a suggestive rather than a therapeutic effect.

ELECTROTHERAPEUTIC APPLICATIONS IN DISEASES.

The question of the real value of electrical applications in various diseases is even at the present time under discussion. Some authors do not believe at all in the curative effect of electricity. Opposed to this absolutely sceptical view there is another which is held by men who believe in the curative value of this agency, but only through its influence upon the patient's mind. This latter influence, it must be admitted, is sometimes competent to remove or allay certain unpleasant symptoms, especially those of a nervous character, which accompany certain diseases. The third view is that which is held by the majority of writers, viz., that the various electric currents do actually exert a curative effect upon certain pathological conditions of the living body. They base their views on: (*a*) exact clinical experiments; (*b*) experiments on animals, in which the psychic effect is out of the question, and in which artificially produced diseases are cured by means of electrotherapeutic methods; and (*c*) the fact that electrical currents show their effect especially on the nervous system. The study of the clinical data concerning the applications of electricity in diseases of various organs permits us to arrive at the following conclusion: the electrical current produces, in addition to the psychical influence already mentioned, the following well-established effects: a chemical effect upon the fluids and solids of the body, an effect upon the smooth muscle cells of the blood-vessels, a stimulating effect upon the nerves, an effect upon striated muscular tissue (contraction), and finally changes in the molecular life of the tissues in general.

DISEASES OF PERIPHERAL NERVES.—(*a*) *Neuralgia.* The irritability of the sensory nerves is diminished by the application of the galvanic anode. The application is made in the following way: one electrode of larger size is thoroughly moistened and applied to some indifferent spot (sternum, back); the smaller electrode is placed on the spot which is considered to be diseased. The number of elements to be used is always determined in advance (on the head and neck they should be fewer than on any other part of the body). With the rheostat we can slowly and gradually regulate the strength of the current, and the galvanometer will show the desired strength. The number of milliamperes shown on the galvanometer will depend upon (1) the localization of the nerve (for the fifth nerve the maximum will be 2 ma., for the brachial plexus about 4 ma., for the sciatic nerve about 8 ma.; (2) upon the length of time during which the disease has existed (in recent cases use weaker currents); (3) upon the sensibility of the individual. Each séance devoted to such an application of the electrical current should not last more than five or six minutes.

Descending galvanic currents are also found to be of value in allaying pain. When we use such a current we should apply both electrodes to the nerve trunk at a certain distance from each other; the anode being placed centrally and the cathode peripherally. Of course this is possible only in cases in which the nerve trunks are not far from the surface. Thus, for example, in cases of sciatica the anode should be placed in the middle of the gluteal fold and the cathode in the popliteal space at the point where the nerve divides into two branches.

In old neuralgias the voltaic alternative currents are used. They are produced by abrupt or rapid movements of the rheostat after both electrodes have been placed according to the general rule.

As to the faradic current it can be used with a faradic brush electrode, which should then be the anode and with which a massage should be exercised over the painful area, while the cathode is kept immovable on an indifferent spot. This procedure will often allay pain.

Cataphoresis with various drugs has been practised by many authors, and comparatively good results have been obtained. According to this method the remedy for relieving pain is applied to the anode which is in contact with the neuralgic area. The cathode is placed on an indifferent spot. By employing cataphoresis with cocaine and with aconitine Peterson and Séguin were successful in relieving patients who were suffering from supraorbital neuralgia.

Treatment by high intensities has been recommended in tic douloureux. An electrode attached to the positive pole is placed on the diseased side, while the indifferent electrode is placed on the back. The current is gradually increased to 30–50 ma. and is allowed to remain at this strength for from half an hour to an hour. Static electricity in the form of sparks is of great utility in neuralgias. One of the methods of Franklinization for allaying neuralgia and various forms of paræsthesia is that of "sharp ends": the positive pole is connected with electrodes which have sharp ends, while the negative is connected with the earth or with an isolated plate for the feet. The electrodes should not be brought nearer the patient's body than at the distance of 2 cm. The conductors must be separated from each other by a distance of from 5 to 8 cm. When everything is in readiness we shall find that light emanates from the ends of the electrodes and that ozone is given forth. The skin, when under the influence of the current, appears to give out a pleasant odor. This form of electricity is used chiefly in the treatment of neuralgias and paræsthesias of all kinds.

(*b*) *Local Cramps, so-called Tics.*—In these affections the mode of employing the current is similar to that already described previously. A *labile application*, however, is the one most likely to prove beneficial. This is effected by applying one electrode at some indifferent point, while the other is moved slowly up and down over the region affected, without interrupting the current.

It is important to bear in mind that while the electrodes are *in situ* and the patient is beginning to feel burning sensations, they should not be removed, because by so doing the sensations in question would simply be intensified.

(*c*) *Paralysis of Peripheral Nerves.*—In the case of peripheral palsies therapeutic effects may be obtained by stimulating the muscles innervated by palsied nerves. The faradic current should be employed. The rules laid down for guidance in electrical examinations should be observed here. The negative electrode is to be placed on an indifferent point, while the positive electrode, supplied with an interrupting handle, should be applied to the affected muscles; the contractions obtained with each closure should be well marked. Both electrodes can also be placed simultaneously on the affected muscle, but if this is done a larger number of closures will be found necessary. The faradic current should not be used in cases in which there are spasms of the affected muscles. The galvanic current is to be used only when there is no response to the faradic. The cathode should be placed upon the affected muscles, while the anode is applied at some indifferent spot. During the passage of the current the cathode is kept moving to and fro over the diseased area without once being removed altogether. After each séance the current should be shut off before the electrodes are removed, especially when the face and neck are under treatment. Both currents, faradic and galvanic, can be utilized at the same sitting if a combination apparatus is employed. When there is no response to the galvanic or the faradic current, it is useless to attempt electrical treatment, and massage should be substituted. When the paralysis or atrophy is followed by contracture of the muscles, electrical applications to the affected muscles should never be attempted. Instead, the attempt may be made to produce a compensatory or counteracting effect by stimulating the muscles which have a function opposite to that of the diseased ones. Thus, for example, if the flexors of the forearm are permanently contracted, the extensors of the limb might advantageously be stimulated, and vice versa.

DISEASES OF THE SPINAL CORD.—In the treatment of diseases of the spinal cord electricity affords a better outlook for improvement, if not for recovery, than does any other method of therapeutics. It can be applied to the cord itself or directly to the different organs dependent upon the parts of the spinal cord that are affected. As to the cord itself two kinds of galvanization are to be used: *stabile* and *labile*. In the first, the positive electrode is to be placed on the neck, while the negative one should be applied to the lumbar region of the spinal column. A current of from 4 to 8 ma. is then to be turned on for about ten minutes. In the second method the anode is to be applied, as before, on the neck, and the cathode is to be moved up and down along the spine without once being removed. This galvanization can be used only in systemic diseases of the cord, in tabes, or in chronic inflammatory conditions (posterior and lateral sclerosis, multiple sclerosis), but not in acute processes like myelitis or hæmatomyelia. In systemic diseases a longitudinal galvanization, in the form of stabile and labile applications, is indicated. By adopting this plan the current will be made to pass through the entire cord. In case a segment of the cord is diseased, as in transverse myelitis of a chronic character, a transverse galvanization is indicated. This may be carried out by placing one electrode over the spine, while the other is applied to the median line in front.

The effect of galvanization of the cord is expressed by a betterment of its circulation and nutrition. Better results, however, will be obtained if the electrical current is applied directly to the organs affected by the disease of the cord. This is true, for example, of the palsies accompanying poliomyelitis or myelitis. In old palsies due to diseases of the cord the faradic current should be used. In cases of spasticity the anodal labile application of the galvanic current should be utilized. In mild palsies the galvanic cathode should be put in use. Paræsthetic disturbances accompanying palsies can be relieved by the application of the galvanic anodal electrode or by using the faradic brush; the latter being especially indicated in cases of sharp pain.

In diseases of the spinal cord the sphincters of the bladder and rectum are often involved, and there are apt to be sexual disturbances. Cases have been reported in which good results were obtained by introducing into the urethra, as far as the bladder, an insulated electrode having the form of a bougie. Before turning on the electrical current (one of 10 ma.) the bladder should be half filled with warm salt water, and after a few minutes the current should be reversed. The faradic current is to be employed, and the external electrode is to be placed against the perineum, the lumbar part of the spine, or over the pubis. The galvanic current may also be utilized, but in that case the bougie-like electrode should be made the cathode. Good results have also been obtained from external electrization; the cathode of the galvanic current having been placed in these cases on the lumbar region and the anode on the perineum or the pubis. The most careful asepsis must be observed.

Impotence due to spinal diseases can be treated with the faradic brush, to be applied over the lumbar region, or with a labile galvanic current.

The question of electrotherapeutics in progressive muscular atrophies is intimately associated with that of *reactions of degeneration.* In each case a thorough investigation concerning the electrical reactions of atrophied and paralyzed muscles is absolutely indispensable, for the reactions of the diseased muscles to electrical currents will determine the nature and seat of the lesion. Also the prognosis of certain forms of paralyses depends almost exclusively upon the electrical reactions. It is therefore essential to say a few words in regard to the electrical reactions in muscular wastings and paralyses.

In diseases which involve the region of the peripheral neurones and which lead to degeneration of muscles one finds abnormalities in the electrical irritability of the affected nerves and muscles. These abnormalities present the following characteristic points:

1. *Quantitative* changes, namely: (*a*) diminution and entire loss of irritability (faradic and galvanic) of the nerves and of faradic irritability of the muscles; (*b*) increase and soon diminution of galvanic irritability of muscles. 2. *Qualitative* changes, especially: (*a*) slowness of galvanic muscular contractions, and eventually (*b*) deviation from the normal formula. If Ca represents the cathode (negative pole), An the anode (positive pole), c the closure, and o the opening, we shall have as the formula for normal nerve reactions to galvanism: CacC > AnoC > AncC > CaoC; and as that for normal muscle reactions: CacC > AncC > AnoC > CaoC. In disease the formulæ will be reversed.

The complicated anomalies of irritability, which accompany muscular degeneration and which disappear when the degeneration is followed by regeneration, were studied first by Erb (1868), Ziemssen, and Weiss; and finally Erb proposed that the corresponding symbol should be RD (reaction of degeneration).

The reaction of degeneration takes place in the following cases: 1. Diseases of the medulla with involvement of the nuclei of cranial nerves (such, for example, as the different forms of bulbar paralysis). 2. Diseases in which the cells of the anterior horns are involved (such, for example, as acute anterior poliomyelitis; so-called infantile palsy;* progressive muscular atrophy; hemorrhage and softening in the anterior horns; tumors, including gliomata; syringomyelia; transverse myelitis; and amyotrophic lateral sclerosis). In diffused foci of an inflammatory or a sclerotic nature, which have their seat in the anterior horns, we find RD in the muscles which derive their nervous supply from the corresponding parts of the cord. 3. Diseases affecting the roots of cerebral or spinal nerves. Among these may be included meningeal processes of various kinds involving also the trunks, tuberculous disease of the columns, and tumors which have their origin in the roots or meninges. 4. Diseases of peripheral nerves: (*a*) Affections due to compression of the nerve (as, for example, the pressure palsies of the arms, peroneal palsy, and palsies of the ulnar and median nerves); rheumatic facial palsies; injuries of nerves in surgical operations. (*b*) Inflammation of nerves (as in the facial palsies which are caused by disease of the middle ear, and in the idiopathic palsies which are partly of a toxic nature—*e.g.*, lead, arsenic, and alcoholic palsies—and partly the result of infection—*e.g.*, the palsies following diphtheria, influenza, etc. (*c*) Tumors of nerves.

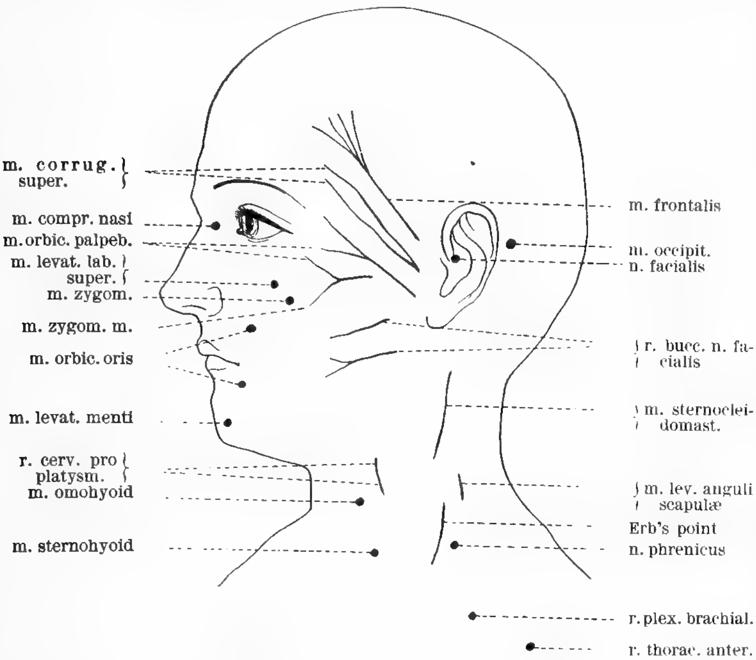

FIG. 1838. Motor Points of Head, Face, and Neck.

The RD may be complete or partial. The complete reaction is observed in two classes of cases: those which are curable and those which are incurable. The curable cases may again be subdivided into the light and the more serious forms. A differential diagnosis between the incurable and the clearly curable cases can be made only after the lapse of eight, ten, or even fifteen weeks after the commencement of the disease. If by that time we notice a return of contractility (under the use of a strong current applied indirectly through the nerves) in one or more muscles located in a region where previously the current had elicited no response, or if such contractility can be excited in these very muscles by a direct application of the faradic current, we may feel warranted in giving a favorable prognosis—*i.e.*, the case in hand belongs to the curable variety. The more muscles respond to direct or indirect stimulation, the better is the prognosis. It is also important to watch the form of galvanic muscular contraction. If the galvano-muscular irritability is low, but the formerly slow contraction becomes rapid, the prognosis as a rule is good; but if it remains slow and becomes even slower, the prognosis is bad; it is probably a completely incurable form of paralysis.

It is important to examine all the muscles of the diseased area by direct stimulation and indirectly (by application of the current to the nerves) in order to ascertain whether all the muscles innervated by the nerves in question contract or not.

We said before that progressive muscular atrophies should be treated with electricity. In progressive muscular dystrophies, in which the palsy and atrophy are not due to involvement of the spinal cord, the faradic contractility is preserved for a very long time, and it is the last to disappear. The galvanic current should therefore be used in these cases, and a labile cathodal application should be made at the beginning and should soon be followed by the faradic current, or a combination of galvanism and faradism may be tried.

The accompanying figures (Figs. 1838 to 1846) will show the exact points where the electrodes should be applied in order to influence certain muscles and nerves of the face and four extremities in cases of paralysis and atrophy.

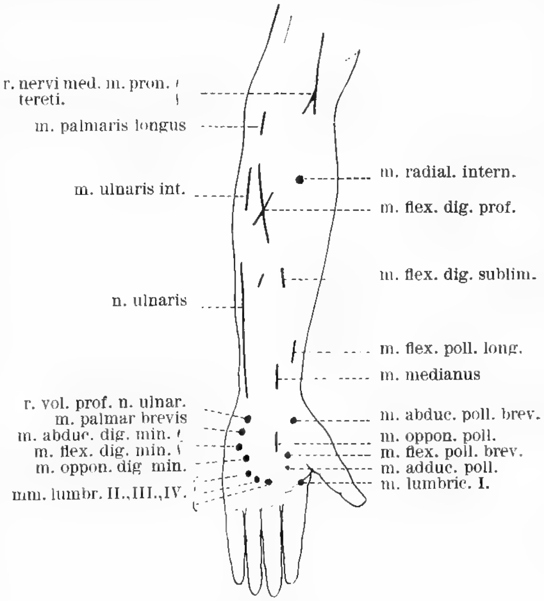

FIG. 1839.—Motor Points of Forearm.

DISEASES OF THE BRAIN.—Galvanization of the head has been resorted to in various diseases of the brain, such as hemorrhages, softening, inflammation, tumors, and atheromatous condition of the arteries, and even in psychoses of all varieties. The methods employed for influencing the brain are: 1. Longitudinal brain galvanization, in which the electrodes are applied to the forehead and occiput. The current may be either stabile or labile. 2. Transverse brain galvanization, in which the electrodes are applied either to the sides of the fronal bones, to the parietal protuberances, to the temporal bones, or to the mastoid processes.

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* In infantile palsies of cerebral origin the electrical reactions show either a simple diminution or else no change whatever, but no RD.

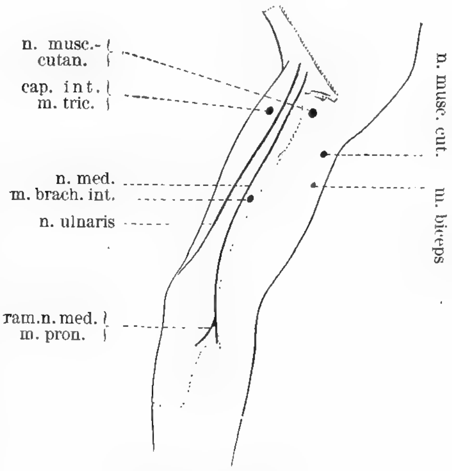

FIG. 1840.—Motor Points of Arm.

The electrical applications to the brain are to be made very cautiously, and the rules above mentioned should be observed very strictly (see rules for applying electrical treatment). As a rule, applications to the brain do not give any permanent result, and if any benefit follows, it is usually by relieving the headache.

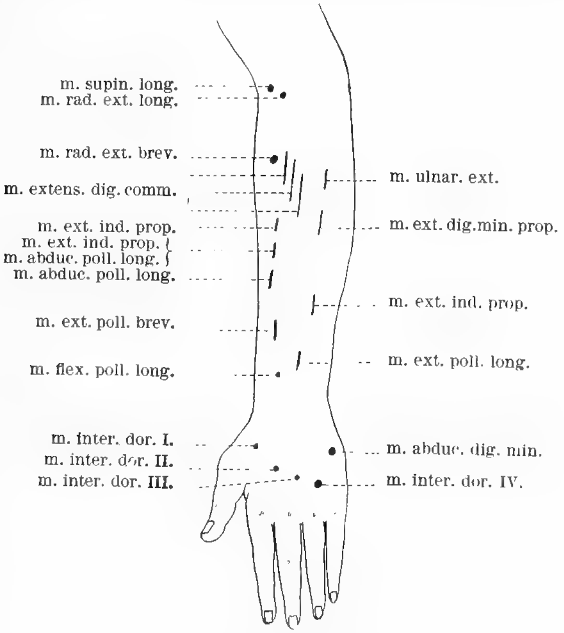

FIG. 1841.—Motor Points of the Extensor Surface of Forearm and Hand.

The application should be made in the following manner: Place the anode on the forehead and the cathode on the neck or sternum, or place both electrodes on the temples. The séance should not last more than five minutes, and a maximum current of 2 ma. should be used. One should rely rather on the sensations felt by the patient than on the strength of the current. Extreme precautions should be taken in galvanization of the head. Relief from headache can be obtained also by galvanization of the sympathetic system in the neck. The anode should be placed on the neck below the ear, behind the ascending perpendicular portion of the inferior maxilla, and the cathode in the jugular fossa. The cathode may also be placed on the corresponding spot on the opposite side of the neck. Very cautiously the current (from 1 to 3 ma.) is to be turned on for a few minutes.

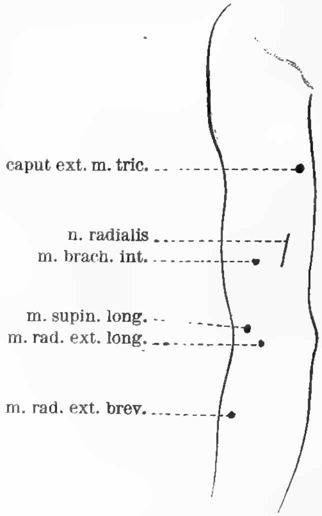

FIG. 1842.—Motor Points of Arm (Extensor Surface).

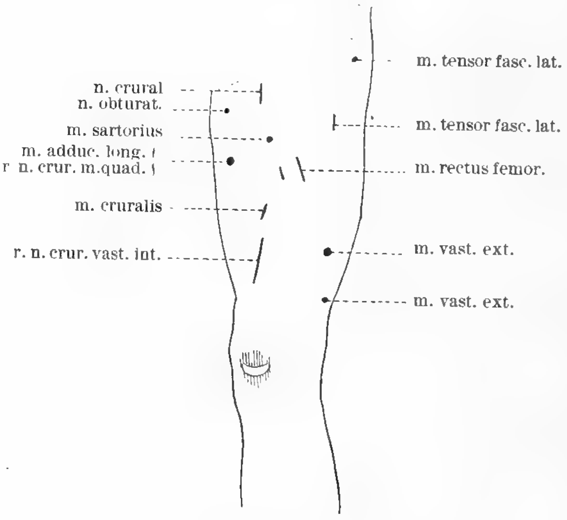

FIG. 1843.—Motor Points of Thigh.

Headaches can also be relieved by means of static electricity, and the following are the methods: 1. *Static douche.* The positive and negative poles and conductors should be held apart and brought near to the patient's body as in the method of "sharp ends" (see above). By means of a short wire the negative pole is connected with the head-plate and the positive with the earth. With the aid of a screw the head-plate may be brought into more or less close proximity to the patient's head or adapted to special parts of the same. The distance separating the plate and the head should not be less than 5 cm. The nearer the plate is to the head the more intense will be the action of the current; and by isolating the patient's body by means of a foot-plate this action can be intensified. The séance should last for from five to fifteen minutes. 2. *Static air bath.* The same procedure as that already described on p. 756. The positive pole is

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connected with a foot-plate or chair, while the negative is connected with the earth. The séance lasts ten minutes. Patient may remain dressed. 3. *Flashes.* Same procedure as that already described. One pole is to be connected with the foot-plate, while the other (generally the positive one), which is connected with a button electrode, is made to approach the patient's body. Even at a distance of 10–30 cm. flashes and lights are noticed, which can be isolated and directed toward one special muscular part. The procedure causes some irritation.

As regards the treatment of cerebral palsies, good is sometimes obtained from the employment of the faradic current provided contractures have not already developed. In the latter case, however, the current should be applied to those muscles which have a function directly the opposite of that of the contracted muscles. For example, if the contracture puts the arm in flexion, a faradization of the extensors can be tried.

FUNCTIONAL NEUROSES.—Electrical treatment in neuroses like hysteria or neurasthenia may sometimes produce a beneficial effect, not because of any specific influence upon the functional disturbances, but rather on account of its suggestive or psychic effect. Any method may be applied in these cases. The tact and ability of the physician in any given case will teach him to what particular method he should have recourse in order to obtain the best suggestive results. On the other hand, there are cases in which electricity, as an adjuvant to massage, will show its really beneficial effect of stimulation. For example, when a general muscular weakness is present, a general faradization will be found very useful. When the circulation is slow, not only in the skin, but also in other organs, a stimulus which will aid the metabolism, respiration, appetite, and general nutrition will be of great importance. The faradic current will produce, in addition to its direct effect on the skin, a reflex action on the central nervous system. The faradic brush or the roller should be applied to the arms, chest, back, and extremities alternately for fifteen or twenty minutes daily, or less often. General galvanization should also be tried. For this purpose the cathode should be placed on an indifferent spot, while the anode, of a smaller size, is to be applied to different parts of the body for about fifteen minutes. A very appropriate electrical treatment in functional neuroses is that by means of the electrical baths (see above).

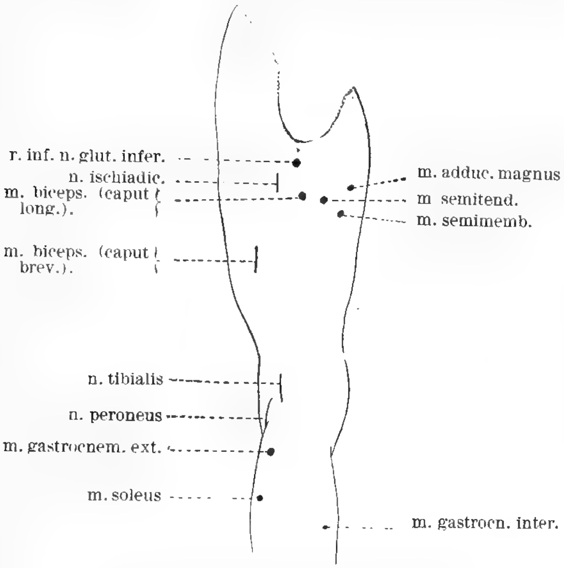

FIG. 1844.—Motor Points of Back of Thigh.

As to individual symptoms in functional neuroses it is possible to influence them beneficially to some extent by electricity. Thus, for example, headaches, no matter of what variety, and insomnia can be relieved in some cases. The method of application is described in the paragraph which treats of diseases of the brain. Other functional symptoms, as paræsthesia, hyperæsthesia, or pain in the back, ovarian region, mammary region, etc., should be treated with the faradic brush or the massage roller. The anodal electrode of the galvanic current may also be tried.

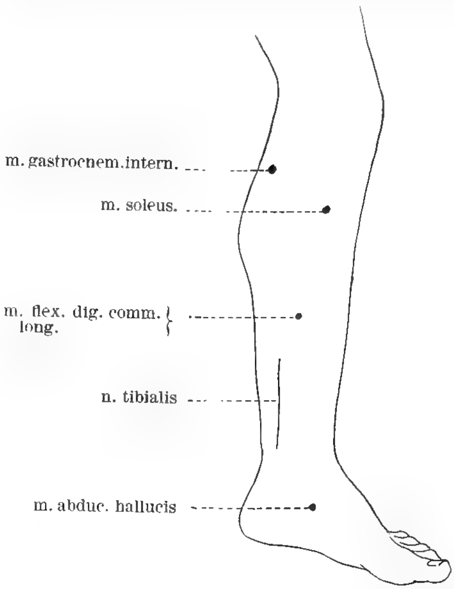

FIG. 1845.—Motor Points of Back of Leg and Inner Border of Foot.

Electricity also shows its beneficial effect in *traumatic neuroses*, like writers', pianists', or tailors' cramp. The motor form of these neuroses, if they are not spastic, can be benefited by an appropriate electrical treatment. The principles are the same as those which govern any other paretic condition of muscles. Local faradization of the

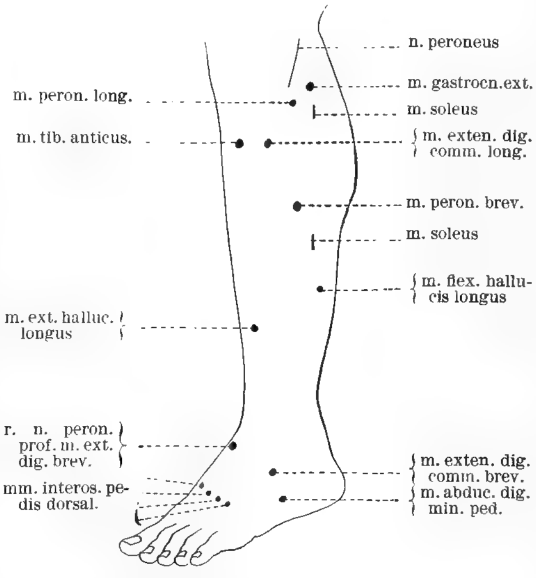

FIG. 1846.—Motor Points of Outer Side of Leg.

muscles, or cathodal galvanization or galvano-faradization, should be applied in the usual manner as described in other parts of this article. In case of *muscular cramps*, if electricity is to be used at all, faradization of the antagonistic muscles should be chosen as the proper procedure. *Tremors* of either a functional or an organic character, like those in multiple disseminated sclerosis, intoxication, etc., should not, as a rule, be treated with electricity, although good results have been reported from the use of electrical baths. The *vaso-motor* or *secretory* neuroses may be treated with galvanization of the sympathetic nerve, but not much should be expected from it.

DISEASES OF THE UTERUS AND ITS APPENDAGES.—Fibroid growth is the most prominent affection of the uterus that can be treated by electricity. The object of this treatment is to relieve pain and hemorrhage, as well as to reduce the size of the tumors. It is supposed that currents traversing such growths cause an inhibition of their proliferating power, some degree of absorption through the lymphatic vessels, and a trophic stimulation of the healthy surrounding tissue. The discovery of the treatment of fibroid growths by means of electricity is due to Apostoli of Paris, France. He demonstrated in the '80's that electricity causes an actual arrest of growth and even retrogression of the fibroid tumors. This was verified by many surgeons, and some of them published cases which were characterized by the actual disappearance of the tumors. The best testimony ever given in favor of Apostoli's treatment is that furnished by the eminent surgeon, Thomas Keith. In his work ("Electricity in the Treatment of Uterine Tumors"), which was written in collaboration with Skene, and dedicated to Apostoli, Keith gave the details of one hundred and six cases treated with electricity. In the introduction to this work he says: "For long we had doubts as to the permanency of the treatment in the early cases. The later work has been much more satisfactory. But now more than two years have passed since all operations were given up for this treatment; and our first patient writes —and no one could have had more hemorrhage—that she has been perfectly well all summer, climbing hills and rowing in a boat. Another of the early and doubtful ones, who could never bear a large dose of electricity, tells us: 'I am now in excellent health, without an ache or pain of any kind, and my periods are just a show, and nothing more, and give me no discomfort whatever. I hope you have been as successful with all your other patients as you have been with me. But it cannot be otherwise, for I am sure that no one could have been worse than I was with that awful hemorrhage.' This patient's importunity had almost driven me into doing hysterectomy for her. At first we fell into the natural mistake of trying electricity on every case that presented any symptoms, in some when the tumors were almost certainly sarcomatous, and even in one who was in the last stages of old cardiac disease. We know now that the cases best treated are those which are suffering much from hemorrhage—the more the better,—cases in which something must be done; cases in which two or three years ago the question of operation of some kind would have been considered by us. This treatment, it must be remembered, is a new thing. We began it in comparative ignorance. Electricity is known by its results, and, working on the living body, progress and improvement are slow. In the following cases, therefore, are found some failures and some imperfect and incomplete cases; the marvel is rather that there are so few. Time and experience every day correct our want of knowledge and diminish these imperfections. No large uterine tumor has with us entirely disappeared under the electric treatment, but in four cases of small fibroids, three of which come into the present series, there is not now a trace to be found. The carrying out of this treatment faithfully to the end is not an easy matter, and old tumors that are large, and that have bled for many years, take a long time to improve. The treatment runs away with time, and it requires care and thought. To the surgeon, by far the simpler plan is hysterectomy and the removal of the ovaries. But Dr. Apostoli's treatment saves our patients from risk of life by operation, and saves them also from a horrid mutilation, the one thing that they all dread. We believe it to be the right treatment, and our patients must get it, however great the inconvenience and monotony it may be to ourselves. Though our results after hysterectomy show the lowest mortality of any yet recorded, and though we have had but a single death after removal of the ovaries for fibroid in almost one hundred operations, we reject even the minor operation in favor of Apostoli's treatment, and we reject hysterectomy altogether on account of the mortality that has hitherto attended it all over the world. The method given us by Apostoli is good, and it will endure. Since we began your treatment, now more than two years ago, we have ceased to perform any operation on the uterus by abdominal section. For myself I have always had grave doubts if I were justified in performing such operations at all, especially hysterectomy, for the mortality attending this operation is out of all proportion to the benefits received by the few. As time went on, and the number of operations became larger, my doubts as to whether I were doing right continued to increase, and that, too, in spite of the comparatively low mortality with which I was favored, more especially in my private practice. I never had any such doubts as to the propriety of performing ovariotomy, for if an ovarian cyst be left alone, death is almost certain, and even that is only reached after great suffering. With hysterectomy it is quite different. Hysterectomy is a hazardous operation for the removal of a tumor that of itself rarely shortens life. The minor operation, on the other hand—the removal of the ovaries—requires no surgical skill for its performance. It is a great mutilation to a woman, being simply castration; and women are beginning to find this out. It is not always successful in attaining its purpose, for you will find in these pages some cases narrated that were cured by electricity where operations on the ovaries had failed to give any relief. Your method thus came to me at a very opportune time. You have taken away from me those anxious doubts and fears that had so long vexed me. For long I had hoped much from electricity in the treatment of fibroids, but had only met with disappointment till your method was made known to me. It is in every way a new method, and it belongs to you and to no other. You have worked in the true scientific spirit. For five years you labored quietly at your clinic, kept up at your own expense, and open to all, before you made your work known. What have those to offer in place of all this who have so bitterly opposed this treatment; who with unlimited material stand aside and will not take the trouble to investigate the matter for themselves, but wait till some one else does it for them; who make only an outcry if by chance they hear of any accident during the progress of the treatment of any case, and who go frantic over the rumor of a death, or worse still, who proclaim they know of deaths that never happen? These men have absolutely nothing whatever to offer in the bad cases, and only hysterectomy in such tumors that will come out more or less easily, so as to be treated by the extraperitoneal method of operating. I have seen not a few cases of bad bleeding fibroids since I came to London; almost every one had consulted one or other surgical authority on the subject of operation. These were invariably told that nothing would do them any good but the removal of the tumor; but in their special case the local difficulties were too great, or they had let their strength go down too far for such an operation. The very feeble and bad cases, with masses of tumor blocking the pelvis, with absence of cervix, and opened-out broad ligaments, would seem to be let alone. Hysterectomy then at best would appear to be a most doubtful remedy for a certain number of cases, and these not of the worst sort. On the other hand, the worse the case, the more feeble the patient, the greater the loss of blood, the more marked is the result of electrical treatment. Given a woman with a large bleeding fibroid, blanched almost to death from years of hemorrhage, and see her some months after this treatment is completed, you would scarcely recognize her, the improvement is so great. Electricity in any form, when applied to the cure of disease, is set down as pure quackery by many medical men, simply because they know nothing about it, and won't take the trouble to learn for themselves what to many is rather a hard study. Every time that any disease can be cured without resorting to a bloody operation, such as hysterectomy, progress is made in our art, and there is a gain to humanity, while surgery is the better for being purged of a deadly operation. It may seem strange to some that after the results I got in hysterectomy—results that almost made it justifiable—I should now begin to throw stones at the operation instead of trying still further to improve upon it. I would give something to have back again those sixty-four women that I did hysterectomy for, that I might have a trial of Apostoli's treatment upon them. What I now plead for is that, for a time, all bloody operations for the treatment of uterine fibroids should cease and that Apostoli's treatment, as practised by him, should have a fair trial."

Method of Application.—The positive pole is the one generally employed, especially in tumors accompanied by hemorrhages. The indifferent electrode (cathode) should be placed on the abdomen, and the active pole (anode) should be inserted into the uterus. In order to protect the os and cervix, the intra-uterine electrode must be insulated. Apostoli uses a sound covered with a sheath of hard rubber. Of course asepsis and antisepsis should be strictly observed. Currents of from 30 to 50 ma. can be frequently repeated. Each séance should last for about five minutes (Apostoli). Stronger currents are permissible only after weak currents have been tried. The current must be taken off very gradually. After each séance the patient must rest for several hours. If on the following day there is pain or some fever, the electrical treatment should be abandoned. As to the effect of the negative pole, it is diametrically opposite to that of the positive; it produces a temporary congestion which will be very beneficial in non-hemorrhagic fibroids. The negative poles may therefore be expected to render very valuable service in fibroids accompanied with amenorrhœa and dysmenorrhœa. *En résumé* we will say, with Apostoli, that the positive pole should be utilized in cases in which there are hemorrhages, the negative pole in those in which there are no hemorrhages.

N. B. The intra-uterine electrode should never be inserted until an examination has proved conclusively that pregnancy does not exist. An acute metritis or some purulent condition of the pelvis is also a contraindication to the employment of an intra-uterine electrode.

Among the tumors which do not yield to electrical treatment, we may mention the fibro cystomata and the myomata.

In cases of metritis and perimetritis, the employment of electricity does not, according to the majority of writers, prove of benefit, except to a certain extent in the chronic forms of these diseases. Apostoli believes, however, that even in the acute stage electricity is not contra-indicated. The methods of procedure are the same as for fibroid tumors.

In diseases of the Fallopian tubes and ovaries again only the chronic forms should be treated with electricity. A vagino-abdominal or a combined intra-uterine and abdominal application of a faradic or a galvanic current may be of use. As to the relative value of these two forms of electricity, galvanization, according to Apostoli, is much more powerful than faradization.

In cases of salpingo-ovaritis, not sufficiently ameliorated by intra-uterine galvanism, Apostoli advises galvano-puncture, which treatment is more efficacious although more painful.

Amenorrhœa and dysmenorrhœa can be benefited by the employment of a strong primary faradic current preceded by a stabile galvanic current of about 30 ma. In the latter procedure the patient should be in the recumbent posture, with her body resting upon a large electrode, while the other electrode should rest alternately on the hypogastrium and the epigastrium. Static electricity with sparks drawn from the lumbar region of the cord, hypogastrium, and loins affords the quickest and most reliable method of treatment. General faradization, dorso-abdominal faradization, and the dry brush applied to the abdominal walls or to the soles of the feet, are reliable methods of application. When galvanization is used in these cases it should be applied either near the centre of the body or along the spine; the current can be directed from the lumbar region toward the pubis. As to direct uterine applications, there is a general opinion that electricity applied not directly to the uterus, but to a distant part, exerts a better influence on the menstrual flow, except when the dysmenorrhœic disturbances are due to stenosis of the cervix or to a deviation of the uterus. In the former condition the proper procedure is to introduce a galvanic cathode into the canal of the cervix; for the relief of the latter, Apostoli employs the current of the secondary spiral of a faradic battery, in connection with his bipolar intra-uterine electrode (Fig. 1847), introduced into the uterus.

Subinvolution is treated by intra-uterine faradic currents. Uterine and ovarian pain of a neuralgic character, accompanied by backache, should, according to Apostoli, be relieved by the faradic current. He recommends the employment of a secondary coil, of a long thin wire, so as to obtain as much tension as is convenient. He uses his bipolar electrode, introduced into the uterus, but external applications—one pole over the sacrum and the other on the perineum or in the groin—are often sufficient. Sometimes a better effect is produced by introducing one of the poles into the vagina.

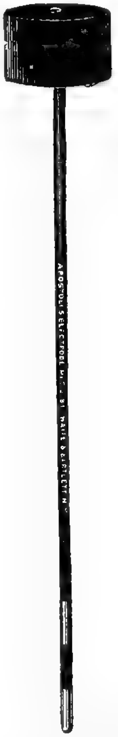

FIG. 1847.—Apostoli's Bipolar Intra-uterine Electrode for Faradic Current.

DISEASES OF URINARY ORGANS.—Electrical applications in paralysis and atony of the bladder due to a spinal affection are dwelt upon in the section relating to diseases of the spinal cord. The same method and rules can be applied in diseases of the bladder of a functional character.

In cases of chronic inflammation and stricture of the urethra the negative pole of the galvanic current should be utilized. The patient should be in the recumbent position, on his back. The indifferent electrode is to be placed on either the abdomen or the back. A whalebone bougie à boule, connected with the negative pole, is to be introduced into the urethra and pushed on until it reaches the painful spot or the stricture. The current should not have a strength above 3, 4, or 5 ma. As the current gradually increases in strength, the bougie will glide onward and pass through the previously contracted and painful canal. If after fifteen minutes the bougie does not pass, defer the application. There should be an interval of at least one week between the applications. At each successive attempt a larger bougie should be used. This treatment of stricture depends for its success chiefly upon the action of the electricity, which causes galvano-chemical absorption to take place—a process which is based upon the electrolytic properties of the tissues of the human body (see the paragraph relating to Electrolysis). No treatment will give more satisfactory results, in a case of irritability of the urethra, than this method of employing the galvanic current. Of course the gentlest manipulation in a necessary element in this sort of treatment.

Hypertrophy of the prostate may also be treated either by electrolysis or by the galvano-cautery. The electrolytic treatment of this affection is the same as that for stricture of the urethra. An insulated bougie-shaped electrode, connected with the negative pole, should be passed through the urethra and its end allowed to rest against the enlarged gland. A current of 5 ma. is then allowed to pass for twenty minutes. The séance can be repeated every ten days.

The use of galvano-cauterization forms a part of Bottini's operation for hypertrophic prostates. The object of this operation is to cauterize and thus divide the prostate. For this purpose Newman's cautery electrode is considered one of the best on the market (Fig. 1848). Tripier advises faradization for hypertrophy of the prostate. The procedure should be carried out in the following manner: An insulated sound is to be introduced into the urethra and a double bulbous electrode into the rectum, and then, after the current has been turned on, the latter is to be pressed against the prostate.

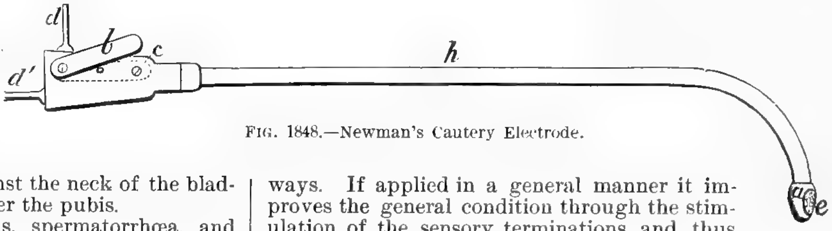

Fig. 1848.—Newman's Cautery Electrode.

Nocturnal incontinence of urine is also benefited by electricity, good results being obtained by the use of either faradism or galvanism. One electrode should be introduced into the urethra and placed against the neck of the bladder, while the other is placed over the pubis.

Involuntary seminal emissions, spermatorrhœa, and impotence are also affections which can be ameliorated or removed by the same method of treatment.

Under these circumstances the cathode should be introduced into the urethra and made to rest against the openings of the seminal ducts, while the anode is placed upon the perineum. In impotence it may be well to add, to the procedure just described, galvanization of the spine and also applications of the faradic brush to the penis and scrotum. It seems proper to state here that two electrical instruments, already described in other parts of the Handbook (Figs. 1570 to 1573 inclusive in the present volume), have been devised for the purpose of facilitating both the diagnosis and the treatment of diseases of the genito-urinary tract. I refer to the urethroscope and the cystocope.

Gout and Rheumatism.—In these affections, which are associated with chronic inflammatory conditions of the joints and with degenerative changes, electrical baths (see above) are indicated. The baths may be either general, if several joints are affected simultaneously, or local, if only one or two joints of a limb are involved. In the last case the affected member is placed in the bath, one pole of the battery is connected by a wire with a metallic vessel submerged in the water of the bath, and the other pole is placed on an indifferent part of the patient's body.

If with the diseased joint is associated muscular atrophy—which, in fact, often occurs—a local faradization of the muscles should be added to the treatment of the joint. Besides the baths direct faradization or galvanization of the joints is of great utility. Stabile unipolar currents, with the anode over the spinal origin of the nerves supplying the joint and the cathode over the joint itself, give good results. Bipolar applications are equally useful. When the faradic current is used, the higher its tension the greater appear to be its analgesic properties. In bipolar treatment the electrodes are placed on both sides of the articulation through which the electrical current passes. At the International Medical Congress of Berlin in 1890 Edison's experiments on the treatment of gout were reported by Bayles; it was demonstrated that the gouty concretions are removed by cataphoresis (electric endosmosis). Good results were obtained by connecting the anti-gouty or the anti-rheumatic drugs with the anode and then directly applying them to the affected joints. The much-desired metabolism, of transforming uric acid into urea, was obtained. The tophi, which in gout are composed of urate of soda, are removed by galvanism, and particularly by the employment of the positive pole; the urates are split at the negative pole.

Muscular rheumatism, lumbago, and rheumatic torticollis may be treated by both galvanic and faradic currents. The method of application is the usual one. Bipolar faradic applications, strong enough to produce vigorous muscular contractions, are the best adapted for the relief of stiffness and spasm. The galvanic current, on the other hand, is more efficacious in relieving pain. The faradic brush also often affords relief in this class of cases. In muscular rheumatism static electricity, as a rule, affords no relief, but the static induction current, with its infinitely rapid succession of sparks, has the character of a faradic current of high tension and, as we mentioned above, it is likely to give relief for a long time.

Diseases of the Skin.—In the treatment of diseases of the skin electricity may be utilized in two different ways. If applied in a general manner it improves the general condition through the stimulation of the sensory terminations, and thus improves the trophic condition of the skin; while if applied locally it removes many uncomfortable symptoms, such as pain, pruritus, hyperæsthesia. Electricity may also produce a caustic effect upon the skin, by depositing acids and alkalies on its free surface. For the production of a general effect, all the three varieties of electricity, static, faradic, and galvanic, may be utilized.

Static electricity is recognized as one of the greatest stimulants of metabolism, and at the same time one of the ideal cutaneous stimulants and sedatives. Faradic electricity acts as a stimulant. The galvanic current produces a sedative effect if a mild current (about 3 ma.) is applied continuously for five minutes. Care should be taken that the skin be slightly reddened; otherwise there may be electrolytic action followed by destruction of the skin. During the operation there should be no interruption of the current. The galvanic current, if applied in sufficient strength, can be used as a counter-irritant. The principle of cataphoresis, *i.e.*, the property of the galvanic current to carry drugs under the skin for absorption, can be utilized in diseases of the skin. The anode should be saturated with the desired drug and applied to the spot where the action of the drug is expected. This method is particularly useful in parasitic affections of the skin; the positive electrode being impregnated with the parasiticide solution and placed over the diseased area. That mercury passes through the skin by this procedure was proven by Gärtner (*Rev. d'Electrothérapie*, 1892). Gautier (*Rev. d'Electrothérapie*, 1891) has proved it for copper, and has applied this treatment in lupus, actinomycosis, and sycosis. Copper needles connected with the positive pole are thrust into the diseased spots; during the passage of the current the copper becomes dissolved and forms, with the oxygen and chlorine of the tissues, an oxychloride of copper, which is highly antiseptic and caustic. The galvano-cautery is utilized for the destruction of diseased tissues, and can therefore be applied in pathological conditions of the skin. Electrolysis is of more use. The tissues are destroyed by an alkali or an acid, whether we use the negative or the positive pole. Acids liberated on the positive pole coagulate the albumen, thus protecting the surrounding tissue from the freed acid. The cathode liberates alkali, which does not coagulate albumen, but acts as a destructive agent. The practical application of this principle in diseases of the skin is evident. A point to be considered is, that the electrode which produces the desired action upon the skin should be a needle and well insulated. The positive pole should be of platinum or gold, because other metals, through undergoing oxidation, leave an indelible stain on the skin. Electrolysis is particularly useful in acne, furuncle, carbuncle, lupus, and epithelioma.

Aneurisms.—In the treatment of the thoracic and subclavian aneurisms in which medicinal aid fails to effect a cure, electricity has been tried with a fair proportion of good results. The employment of electricity in the treatment of aneurisms is based on the fact that a galvanic current passing through the blood coagulates it, through electrolysis. A clotting occurs around the poles, and then subsequently a further coagulation takes place and fibrin is deposited around the primitive clot. Ciniselli treated twenty-three cases, six of which recovered. He operated with needles connected with both poles and introduced into the aneurismal sac; every five minutes he reversed the current. Tripier and others advocate the insertion only of the positive pole, on account of its power to coagulate albumen. Stewart reports good results with continuous currents; the anode being introduced into the sac, and the cathode placed on the abdomen. The strength of the current may be gradually increased up to as high as 70 ma., but one should commence with 20 ma. Each séance should last about half an hour. Petit ("Dictionnaire Encyclopédique") treated 114 cases of aortic aneurism with electrolysis; 69 were improved.

Aneurisms of the extremities were completely cured. Whether the positive pole should be inserted into the sac, or the negative, or both at the same time, as some authors advise, is a matter which has not been fully determined; but one should always bear in mind that hemorrhagic inflammation of the sac, with suppuration and embolism, may occur. In those cases in which the operation proves successful, the tumor hardens and shrinks. *Alfred Gordon.*

ELECTROTONUS.—If a constant battery current flows continuously through a muscle or a nerve, it will so alter the chemico-physical condition of the living substance that its physiological properties will be greatly modified. The modifications produced by the flow of the current were first carefully studied by DuBois-Reymond, who gave the name "electrotonus" to the changed condition. The alterations produced are in general of opposite kinds at the anode, the place where the current enters, and the cathode, the place where the current leaves the tissue; therefore we speak of anelectrotonic and catelectrotonic effects of the current. Where the tissue is under the influence of the anode, is in a state of anelectrotonus, the irritability and conductivity are decreased or even absent; where the tissue is under the influence of the cathode, is in a state of catelectrotonus, the irritability and conductivity tend to be enhanced. These alterations of physiological activity are accompanied by changes in the electrical condition in the vicinity of the two poles, changes which are revealed by the so-called "electrotonic currents."

In the case of muscle, the alterations produced by the current are chiefly localized at the points to which the electrodes are applied; in the case of nerves the change spreads not only throughout the region between the electrodes, the intrapolar region, but in both directions beyond the part directly exposed to the current, the extrapolar regions. Finally, it must be stated that the current not only influences the condition of the nerve and muscle during the time it is flowing, but leaves behind it important after-effects, these being in general the reverse of those observed at the poles during the flow.

The causes of the physiological changes which result from the passage of the current are to be sought in the chemico-physical changes which it produces in the living substance. The flow of the current causes, through electrolysis, the liberation of ions, which in turn produce the polarization phenomena observed. These polarization phenomena are without doubt closely related to the changes in irritability and conductivity, and to the excitation effects produced by the polarizing battery current.

The above facts have been ascertained chiefly through the study of isolated nerves and muscles of animals. There is reason to believe, however, that they hold good for the nerves and muscles of man, although necessarily modified by the spread of the current through the fluids which normally surround these structures.

Effects of the Constant Current upon Irritability and Conductivity of Nerves.—Many of the phenomena referred to by the earlier writers under the title of "galvanism" were of electrotonic nature, but most of the accounts are too vague or the data are too incomplete to make the statements of any scientific value. According to Pflüger, the first trustworthy observation which bears directly on the effect of the galvanic current on irritability and conductivity was reported by "that indefatigable experimenter, Ritter" (Gilbert's *Annal. d. Physik*, Bd. vii., S. 477–483). Ritter stated that he remained connected with a battery by his hands for half an hour, and that the hand and arm on the silver side of the battery (negative pole) became stiffened, and gradually the power to move that hand lessened, while his control over the hand connected with the zinc side (positive) increased. Toward the end of the experiment he had ceased to receive any direct sensations of a type to remind him that he was connected with the battery. Ritter's philosophical interpretation of these effects need not be considered, for his results may be explained in the light of the facts which have been ascertained by scientific study of the effects of battery currents on animal tissues.

Pflüger gives the following explanation: On account of the wide spread of the current through the fluids of the tissues of the trunk, we can think of the current ascending one arm, leaving it at the shoulder to spread through the body, then entering the other arm, descending through it, and leaving it at the hand; thus the first arm has an anode at the hand and a cathode at the shoulder, and the other arm has an anode at the shoulder and a cathode at the hand. Experiments on isolated nerves show that exciting a nerve above a descending current excites less than exciting it above an ascending current, and Ritter's observation is in harmony with this result, and is more interesting because in his case the irritant was the normal voluntary impulse. Ritter ("Beiträge zur näheren Kenntniss des Galvanismus," etc., Jena, 1802, Gehlen's *Journal f. d. Chem., Phys., u. Mineral.*, vi., S. 421, 1808) made other interesting observations of fundamental importance. One of these was that the effect of the current on the nerve increases with the time of closure, this being revealed by the modifications of irritability observed when the current was opened. Another observation was that the modifications produced in the nerve by the current may not be limited to the region subjected to the current, but may spread with opposite sign along the nerve toward the muscle, as depression of irritability where there was an ascending, and elevation of irritability where there was a descending current, what we now recognize as the anelectrotonic and catelectrotonic effects.

Twenty years later another discovery having an important bearing upon our question was reported by the physicist Nobili (*Annal. de Chimie et de Physique*, p. 30, 1830). He saw a frog preparation, which had entered into tetanus from some unknown cause, become quiet when a battery current was passed through it. He explained the result as due to a change produced by the current—this change preventing the transmission of the excitation process. He even went so far as to recommend the use of the constant current to the physician as a means of arresting tetanus.

This subject was studied by Matteucci (Compt. rend., vi., 680, 1838) and others, but the first to do really careful work upon it was Valentin ("Lehrbuch d. Physiol. des Menschen," ii., 2, S. 655). He excited a nerve at a distance from the muscle with an induction current and noted the height of the contraction; then he sent through a part of the nerve, close to the muscle, a constant current, and saw the contraction of the muscle lessen or altogether fail; finally he removed the constant current, and on exciting with the induction current again, saw the muscle contract. The result of this experiment was to show that the nerve could be the seat of the inhibition. Valentin found in addition that excitation might fail when the irritant was applied to the region between the part of the nerve subjected to the battery current and the muscle; but he observed that this occurred only when the ascending, not the descending, current was used.

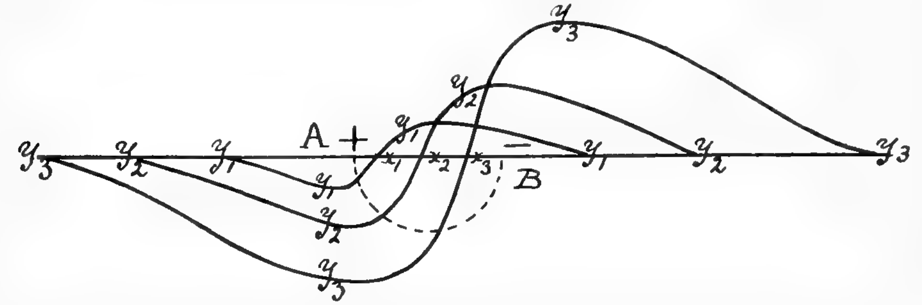

FIG. 1849.—Effect of a Constant Battery Current on the Irritability of a Nerve. The nerve being taken as the abscissa, positive ordinates represent increased and negative decreased irritability. *A*, Shows the point where the current enters; *B*, where it leaves the nerve. Curve *y 1*, shows the irritability caused in different parts of the nerve during the flow of a weak current; *y 2*, by a medium current; *y 3*, by the strongest current.

The next to investigate these questions was Eckhard ("Der galvanische Strom als Hinderniss der Muskelzuckung"; Henle and Pfeuffer, *Zeitschr. f. rat. Med.*, N. F., Bd. iii., S. 198). He corroborated Valentin's statement that a constant current flowing through a nerve makes it impassable for an irritation developed in it higher up; and he proved that this was true for mechanical and chemical as well as for electrical stimuli. Eckhard (*Beiträge z. Anat. u. Physiol.*, Heft i., S. 25, 1855) also observed, like Valentin, that the ascending current can lessen the excitability between the positive electrode and the muscle, and found, in addition, that the descending current can increase the excitability of the nerve between the negative electrode and the muscle. This was observed to be true when chemical stimuli were used. He failed to find the increased irritability which occurs near the cathode when the current is ascending.

Although the work of his predecessors had revealed many of the more important effects of the flow of a constant galvanic current through a nerve, we are indebted to Pflüger for a critical review of the field, and for the disentangling of apparently conflicting results. He devised exact methods for grading the strength of the polarizing current, for securing a constant strength of stimulation, and for recording the height of the muscular contractions which he used as the test of the strength of the excitation developed in and transmitted by the nerve. With the help of these methods he was enabled to distinguish more accurately than had been done the effects of the polarizing current on conductivity and on excitability. He sums up the results of his studies on the effect of the polarizing current on the irritability of the nerve when it is excited by an induced current as follows ("Unters. ü. d. Physiol. d. Electrotonus," S. 47, Berlin, 1859):

I. We send a constant descending current through a stretch of nerve near to the gastrocnemius muscle and lay the electrodes of the induction circuit near the positive electrode and between this and the central cut end on the sciatic nerve. A descending induction current now causes a weaker contraction when the nerve is polarized, a stronger when it finds itself in the normal condition.

II. The constant descending current flows through a stretch of the nerve near the cut end, and the irritating descending induction current strikes the nerve in the vicinity of the negative electrode and between this and the muscle. The contractions now appear stronger than when the constant current does not flow through the nerve.

III. The constant ascending current flows through a stretch of the nerve near the gastrocnemius muscle, and an ascending induction shock strikes the nerve in the neighborhood of the negative electrode and between this and the central cut end. While the constant current flows, the contractions are larger than when this is not the case.

IV. The constant ascending current flows through a stretch of nerve in the vicinity of the cut end, and an ascending induction shock strikes the nerve near the positive electrode and between this and the muscle. While the constant current flows, the contractions are weaker than when this is not the case.

If the strength of the current surpassed a certain amount, inhibitory effects on the conduction power of the nerve, like those described by Valentin and Eckhard, were seen.

Thus Pflüger found that the excitability of the nerve in the extrapolar regions was decreased near the anode and increased near the cathode, both when the polarizing current was ascending and descending, and in the region central as well as peripheral to the part subjected to the current. In short, the irritability of the nerve during the flow of the current is decreased in anelectrotonus and increased in catelectrotonus.

Pflüger also observed, by the use of chemical stimuli, that the irritability is altered in the intrapolar regions. Since the irritability is here, as in the extrapolar regions, decreased at the side of the anode and increased at the side of the cathode, there is an indifferent point at some place between them where these effects neutralize each other.

Pflüger found that as the polarizing current is strengthened the anodic depressing influence predominates more and more and the indifferent point shifts toward the cathode. He gives the following scheme (Fig. 1849), to illustrate the alteration of the irritability of the nerve in electrotonus by different strengths of battery current.

Although the most striking effect of the cathode is to increase the irritability of the nerve, a number of observers* have reported that a strong current, if allowed to flow for a considerable time, may cause a subsequent depression of the irritability. This fall of irritability in the region of the cathode has generally been attributed to a spread of the condition of decreased irritability at the anode into the region of the cathode. The indifferent point is said to shift, as the current is strengthened, toward the cathode; until finally the cathodic region is invaded and the irritability is depressed beneath the cathode. Results obtained by Werigo (Pflüger's *Archiv*, xxxi., S. 417, 1883; *ibid.*, lxxxiv., S. 547, 1901), and confirmed by the experiments of Burker (Pflüger's *Archiv*, lxxxi., 1890) throw doubt on the usually accepted explanation. According to Werigo, the fall of irritability at the cathode is not the result of anodic influence, but is an effect produced by the cathode. The first effect of the closure of the current is to heighten the irritability at the cathode, and this condition of heightened irritability extends from there with lessening intensity in both directions along the nerve; this condition of increased irritability soon gives place, however, to a decrease of irritability immediately beneath the cathode, the irritability in the intrapolar and extrapolar regions to either side of it remaining high. If the current is long-continued, the cathodic decrease of irritability spreads along the nerve to either side of the pole.

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* Hermann (Pflüger's Archiv, vii., S. 354, 1873; *ibid.*, x., S. 226, 1875), Gruenhagen (Pflüger's Archiv, iv., 1871), Tigerstedt ("Mitth. a. d. physiol. Lab. d. Carolin. Institut. in Stockholm," Bd. i., 1875), who used mechanical excitations for the intrapolar region, Zanetowski ("Sitzbr. d. k. Akad. d. Wiss. in Wien, Math. Phys. Cl.," Bd. cvi., Abthl. 3, S. 185, 1897), Lhotak v. Lhota (Bull. internat. d. l'Acad. d. Sc. d. Bohème), Hermann and Tschitschkin (Pflüger's Archiv, lxxviii., S. 53, 1899), and Gotch (Schaefer's "Textbook of Physiology," ii., p. 495, 1900).

The changes in irritability which take place when a battery current is put into a nerve begin immediately. We shall consider this question later, in connection with electrotonic currents.

After-Effect of the Current.—In the early days of galvanism it was observed that when the current is withdrawn from a nerve it leaves it in an altered state. The first observations related to the excitation phenomena accompanying the opening of the current. The opening contraction was seen first by Valli and Fowler (Reinhold's "Geschichte des Galvanismus," u.s.w., S. 35, 1792), the opening flash by Rutherford, and the opening sensation by Robinson (Al. Monro's and Richard Fowler's "Abhandlung," S. 57, 1793). Both Volta ("Collezione dell' Opere," T. ii., p. 11; letter to Banks "Memoria sully Idendita," p. 219) and Pfaff ("Ueber thierische Electricität u. Reizbarkeit," S. 76) failed to recognize the true significance of the opening contraction, referring it to changes occurring in the battery circuit at the instant it was broken. Ritter ("Beiträge z. näheren Kenntniss d. Galvanismus," Stuck. i., S. 78, 1802) attributed it to an effect left in the organism, saying that the instant the battery circuit was broken its influence must cease. This view was supported by Ermann (Gilbert's *Annalen d. Physik*, xxiii., S. 30, 1806) and Dumas ("Traité experimental," T. iv., S. 968, p. 284, 1836) and has been generally accepted. Ritter's view is favored by the fact that the opening tetanus observed by him with the ascending current is the greater the longer the current lasts (Ritter, "Beweis dass ein beständiger Galvanismus den Lebensprocess in dem Thierreich begleite," S. 119–121, 1798). Pflüger ("Electrotonus," S. 72, 1859) in treating of this subject accepts Ritter's idea that the opening tetanus is due to an equalization of the alterations produced by the current in the nerve, the molecules being carried back to normal position by internal forces. He points out, however, that the visible excitatory phenomena are only the outward expression of changes produced in the nerve by the current, and that the current leaves behind it alterations which manifest themselves in a change of the irritability. In general at all points where the irritability is raised during the flow it is lessened just after its removal and vice versa. Pflüger ("Electrotonus," S. 274) states that the fall at the cathode is of short duration, however, and is followed by a second rise, while the rise at the anode lasts for a considerable period. The decline of excitability at the cathode when the current has been strong is of so short duration that, according to Obernier (*Archiv f. Anat. u. Physiol.*, S. 269, 1861), it may be difficult to detect it. Werigo (Pflüger's *Archiv*, lxxxiv., S. 547, 1901) states that the after-effect of the current depends more upon the duration of flow than upon the strength of the current. If the flow is of short duration the recovery is very rapid; if it is prolonged, a condition of decreased irritability may last for a long time. A reversal of the current, making the former anodic region cathodic, hastens the return of the irritability to the normal.

Effect of the Constant Current on the Conductivity of the Nerve.—Pflüger ("Electrotonus," S. 48) found, like Valentin and Eckhard, that if the current surpasses a certain strength, it has an inhibiting effect on the conduction power of the nerve. To demonstrate it, it is only necessary to excite the nerve by a feeble stimulus applied to the central end of the nerve of a nerve-muscle preparation, and then let a battery current flow in either direction through the part of the nerve between the excited point and the muscle. The flow of the current lessens the conductivity of the nerve in the region of the anode and the muscle fails to be excited. This block at the anode is thought to be associated with the lessened excitability of this region by those who regard the conduction process to be due to the successive stimulations of succeeding points of the nerve. After the removal of the current there is, for a short time, a block in the region of the cathode corresponding to the decreased irritability in this region. Like the decrease in irritability, the decrease in conductivity is greater the stronger the battery current and the longer the closure. The lessening of conductivity during the closure and just after the opening of the battery current explains the third stage of Pflüger's law of contraction. If the current is strong and the anode be nearest the muscle, the excitation developed at the cathode on the closure of the current fails to be transmitted; and if the cathode is next to the muscle, the excitation developed at the anode at the opening is prevented from reaching the muscle. This experiment shows that the change in conductivity, like the alteration of irritability, begins immediately.

Not only is the power to conduct lessened during the flow of the current, but von Bezold ("Electr. Erreg. d. Nerven u. Muskeln," Leipzig, 1861) has shown that the conduction rate is slowed. This result has been corroborated by the work of Rutherford (*Jour. of Anat. and Physiol.*, ii., p. 87, 1867) and Gotch (Schaefer's "Textbook of Physiol.," ii., p. 502, 1900), who also found that with weak currents of short duration the conductivity is quickened at the cathode. We should expect to find the conductivity at the cathode to be lessened during the flow of the current, if it is strong and long-continued (Werigo, Pflüger's *Archiv*, lxxxiv. S. 547, 1901).

Electrotonus in Human Nerves and Muscles.—Electrotonic phenomena in man are of great interest not only because of their theoretical import, but because of their bearing upon diagnosis and therapeutics. Unfortunately the conditions under which the nerves and muscles exist in the normal man are such as to make exact experimentation impossible. In spite of the difficulties which exist, it has been ascertained that the voltaic current has the same effect upon the nerves and muscles of men as upon those of the frog and the higher animals.

In studying the effect of the battery current on the nerves of man one has to resort to the unipolar method, recommended by Chauveau (Compt. rend., lxxxi., p. 779, 824, 1875; lxxxii., p. 73, 1876). By this method, a large electrode is placed over some indifferent part of the body, and a small electrode is put directly over the part to be subjected to the current. The position of this electrode does not accurately mark the point at which the current will enter and leave the nerve because the current spreads as it enters the moist tissues beneath the electrode.

Hermann ("Handbuch d. Physiol.," Bd. ii., Abth. 1, S. 62, 1879) states that one can never be sure of the direction which the threads of the current will take in the nerve. If the exciting electrode is the anode, it will frequently happen that there is a catelectrotonic region above and below the point of application of the electrode. Moreover, because of its spread through the fluids about the nerve, the current does not enter and leave the nerve at two definite places, but there are formed, beneath the physical anode, the leading-in electrode, and beneath the physical cathode, the leading-out electrode, many physiological anodes and cathodes. It is at these physiological anodes and cathodes, the places where the current enters and leaves the nerve, that its anelectrotonic and catelectrotonic effects are produced. The position and number of these physiological poles will of course be different in each experiment.

It is not strange that working under such variable conditions different observers have arrived at contradictory results.

Fick ("Medicin. Physik," S. 377, 1866) tried by applying the current to the ulnar nerve at the elbow to get inhibition of voluntary muscular contractions, but failed to do so even with very strong currents. Eulenberg (*Deutsch. Archiv f. klin. Med.*, iii., 1867) obtained, on the nerves of men, changes in irritability closely resembling those obtained by Pflüger on the nerves of frogs. Erb (*Deutsch. Archiv f. klin Med.*, iii., 1867) at first found a decrease of irritability near the cathode and an increase near the anode. Later, however, his attention having been called by Helmholtz to the way in which the current spreads, he repeated his experiments and decided that the nerves of men behave like those of animals (Ziemssen's "Patholog. u Therapie," iii., S. 90, 1882). Samt, Bruecker, Runge, and Ziemssen also studied this question but failed to obtain uniform results.

De Watteville (Thèse inaug., 1883) reached the conclusion that human nerves react like those of frogs to the battery current; and Waller and de Watteville (Philos. Trans. Royal Soc., London, 1882) obtained definite proof that the irritability of the human nerve is decreased in anelectrotonus and increased in catelectrotonus. Waller ("Lect. on Physiol.," first series, on Animal Electricity, p. 81, London, 1897) describes the following experiment: A large flat electrode is placed on the back of the neck and the knob of a small electrode over the ulnar nerve at the back of the elbow. The electrode is pressed carefully upon the nerve, and then tapped at regular intervals with a light mallet, just hard enough to give distinct twitches of the fingers. If while these light blows are being given the current is sent into the nerve, the electrode being made a cathode, the effect of the taps is seen to be more pronounced; if the current is then reversed, and the electrode is made an anode, the taps are seen to be without effect.

Excitation Effects of the Voltaic Current.—Not only does the voltaic current produce alterations within the nerve which greatly modify its irritability and conductivity during the flow and after the withdrawal of the current, but it causes excitation effects at the instant that the current begins and at the instant that it ceases to flow through the nerve. These excitation effects are intimately related to the electrotonic changes produced by the current, and, to be understood, must be considered in this connection.

The amount of excitation depends on two sets of conditions: those conditions of nutrition, etc., which determine the excitability, the molecular stability, of the nerve as a whole; and those conditions which determine the extent and character of the electrotonic changes which occur at the two poles. This latter set of conditions are, viz., the strength and density—*i.e.*, the intensity of the current; the rate of change of intensity; the duration of the current; and the length of nerve subjected to its influence.

It has been frequently pointed out that a rise of irritability is closely associated with increased molecular instability. If the change be sufficiently sudden there may be molecular disintegrations which result in the liberation of energy and the development of an excitation process. At the instant the current is sent into a nerve, there is a sudden rise of irritability at the cathode, from the normal to something above the normal, and a fall at the anode, from the normal to something below the normal. When the current is opened the reverse is true: a sudden rise of irritability at the anode, from below the normal to a level above the normal, and a fall of irritability at the cathode, from a point above the normal to a level below the normal. The sudden rise of irritability and sudden increase of molecular instability occurring at the cathode when the current is closed, and at the anode when it is opened, cause an excitation process to develop at the cathode on the closing and at the anode on the opening of the current.

Pflüger* stated his "law of polar excitation" as follows ("Untersuchungen," S. 456): "A given stretch of a nerve is irritated by the development of catelectrotonus and the disappearance of anelectrotonus, but not through the disappearance of catelectrotonus or the development of anelectrotonus."

The cathode closing effect is the stronger and is the only one seen when the current is weak; as the current is strengthened the anode opening excitation also develops, so that by medium currents both closing and opening effects are seen. By strong currents, these excitation effects are rendered still stronger; but a new condition begins to show itself, viz., the effect of the current on the conductivity. The conductivity of the nerve suddenly lessens at the region of the anode at the instant the current is closed, and at the cathode at the instant the current is broken, and if the current be strong the decrease of conductivity acts as a block for excitation processes developed higher up.

The results of the excitation of the nerve of the frog, by making and breaking battery currents of different strengths and different directions, have been formulated by Pflüger ("Electrotonus," S. 454) as follows:

PFLÜGER'S LAW OF CONTRACTION.

Current.	ASCENDING.		DESCENDING.	
	Closing.	Opening.	Closing.	Opening.
Weak	Contraction.	Quiet	Contraction.	Quiet.
Medium	Contraction.	Contraction.	Contraction.	Contraction.
Strong	Quiet	Contraction.	Contraction.	Quiet.

The same law is found to hold good for afferent nerves, the reflex response being taken as the index, only in this case the organ to be excited being at the central end of the nerve, the effects of descending and ascending currents are reversed.

That the closing excitation is developed at the cathode and the opening at the anode may be proved by subjecting special regions of the nerve to agents which will alter the irritability. Gotch and Macdonald (*Journ. of Physiol.*, xx., p. 257, 1896) found that if the irritability of the nerve be raised at one pole by the cooling of that part of the nerve, and lowered at the other by warming the part, one obtains with suitable strengths of current an excitation only from the pole that is on the cooled region, a closing if this is the cathode, an opening if this is the anode. Similar results are got if the irritability of the nerve is locally raised by the application of NaCl and locally lowered by the application of ammonia.

Effect of Rate of Change.—DuBois-Reymond formulated his "law of excitation" as follows: "It is not the absolute value of the current at each instant to which the motor nerve replies by a contraction of its muscle, but the alteration of this value from one moment to another; and, indeed, the excitation to movement which results from this change is the greater the more rapidly it occurs by equal amounts, or the greater it is in a given time." Although this rule is not without exceptions, the general statement holds good that excitation effects fail in case catelectrotonic changes develop and anelectrotonic changes pass off gradually; the suddenness with which the equilibrium of the nervous molecules is altered appears to play an important part in producing what we call the nerve impulse. For this reason the rate at which the change of intensity of the existing current occurs has a marked influence on the result, and within certain limits (varying with the special type of nerve) the more rapid the changes the greater the exciting effect.

Effect of Duration of Current.—The catelectrotonic and anelectrotonic states do not develop with equal rapidity, the former developing very rapidly and the latter somewhat more slowly. For this reason, weak currents of short duration excite only on the closure, at the cathode. This is true of brief voltaic currents, breaking induction currents and condenser discharges. Anodic excitations with induced currents are to be obtained only when very intense currents are used.

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* The statement is not infrequently made that Chauveau (Jour. de Physiol., ii., pp. 490-511; *ibid.*, pp. 553-576, 1859) discovered the "Law of Polar Excitation." Those who are interested in this subject are referred to the article by Pflüger, Pflüger's Archiv, xxxi., S. 119, 1883.

Effect of Length of Nerve.—That excitation fails when the electrodes are applied to the opposite sides of the nerve is due not to the resistance, although this is increased, but to the fact that the antagonistic anelectrotonic and catelectrotonic effects neutralize each other. On the other hand, we find that the effect of irritation is the greater the longer the stretch of nerve between the electrodes, because the further they are apart the more complete the anelectrotonic and catelectrotonic changes.

The Opening and Closing Tetanus.—Ritter observed that if a strong ascending current flows through a nerve for a considerable time, on the opening of the circuit the muscle enters into vigorous continued contraction, which only gradually passes off. This phenomenon has received the name of Ritter's opening tetanus. The excitation develops at the anode, as is shown by the fact that it persists after the nerve is cut above the anode in the intrapolar region. The cause of the excitation is to be found in the anelectrotonic chemical changes which have been produced during the flow of the current, and which, because widespread, require considerable time for their disappearance. The tetanus ceases at once if the current is again closed, and the decrease of irritability which exists at the anode when the current is closed is again established. On the other hand, the tetanus becomes still stronger if the current be closed in the reverse direction, and the irritability in the region of the former anode is now still further increased by putting that region into a condition of catelectrotonus.

If the irritability of a nerve be increased by some agent, a salt or a mechanical influence, for example, but not enough for the state of heightened irritability to pass over into a condition of excitation, the closure of the current, by still further increasing the irritability at the cathode, will cause a closing tetanus.

These effects can be summed up as follows: If the irritability of a nerve be heightened by any influence of a kind to produce a condition of latent excitation, this state manifests itself by a continuous excitation starting at the cathode on the closure, and at the anode on the opening of the current. There are some nerves, especially the non-medullated of crayfish, which under normal conditions show prolonged closure effects in a very striking manner, and Biedermann ("Elektrophysiologie," S. 596, 1895) argues that the medullated nerves of voluntary muscles, although normally excited only by the make and break of the current, may under altered conditions respond as well to the polar changes resulting from a prolonged flow of the current.

The Law of Contraction for Human Nerves.—The law of contraction which applies to human nerves under normal conditions differs considerably from the law of contraction established by Pflüger for the isolated nerves of frogs. The differences are, however, more apparent than real, and are readily reconciled if one takes into account the conditions under which the work is done. The so-called unipolar method is used for the excitation of human nerves (see page 769). By this method both opening and closing effects are to be obtained beneath the positive and beneath the negative electrode, because under each of these there are physiological anodes and cathodes where the current enters and leaves the nerve. This condition is illustrated in the following figure.

The current enters the nerve beneath the anode, and leaves it beneath the cathode as a comparatively dense stream; but where it leaves the nerve beneath the anode and enters it beneath the cathode, the stream is diffused. These differences in density play an important part in determining the reactions.

The current spreads widely as it passes from or to the electrodes through the nerve, so that to either side of the anode and cathode the current is flowing in both directions along the nerve: for this reason we cannot find the effects of direction of current such as show themselves on the isolated nerve.

Closing excitations developing at the physiological cathodes, when the nerve passes from the normal state to one of catelectrotonus, always tend to be stronger than opening excitations, developing at the physiological anodes, when the nerve passes out of the state of anelectrotonus. Of the two closing and two opening excitations, that which occurs where the density of the current is greater is the stronger.

If the effect of closing and opening excitations be tested at the positive and negative electrodes with gradually increasing strengths of current, under normal conditions the following order will be observed, viz.:

1. Cathode closing contraction (KCC), *i.e.*, the contraction which results from the development of catelectrotonus at the physiological cathode beneath the physical cathode.

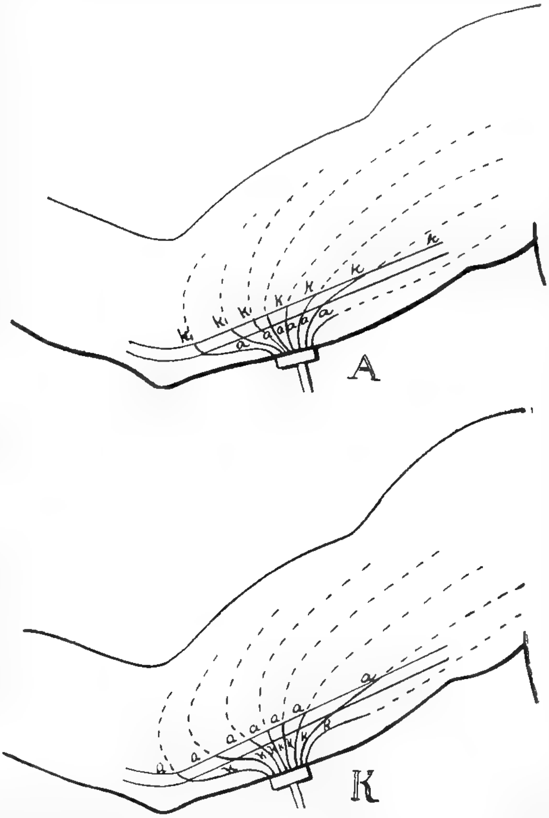

FIG. 1850.—Unipolar Excitation of Human Nerve. *A*, The positive electrode, the physical anode; *K*, the negative electrode, the physical cathode; *a, a, a*, physiological anodes; *k, k, k*, physiological cathodes.

2. Anode closing contraction (ACC), *i.e.*, the contraction which results from the development of catelectrotonus at the physiological cathode beneath the physical anode.
3. Anode opening contraction (AOC), *i.e.*, the contraction which results from the cessation of anelectrotonus at the physiological anode beneath the physical anode.
4. Cathode opening contraction (KOC), *i.e.*, the contraction which results from the cessation of anelectrotonus at the physiological anode beneath the physical cathode.

It is convenient to describe the results in three stages, corresponding to weak, medium, and strong currents.

First stage, only KCC is seen.

Second stage shows KCC (stronger), ACC and perhaps AOC, the latter being feeble, or more rarely AOC being stronger than ACC, these variations depending on differences in the density of the current due to relation of nerve to surrounding tissues.

Third stage gives all four contractions, the KCC being vigorous and prolonged, tending to take on the character of a continuous contraction (the closing tetanus), and the

KOC being very feeble. By this third stage the coming of the AOC may be delayed. Waller (*Archives de Physiol. normal et Pathol.*, p. 383, 1882) finds this delay may be as much as 0.3 second, and attributes it to the loss of conductivity which occurs in the region of the physiological cathode for a short time after the opening of the current.

Effect of the Voltaic Current on the Irritability and Conductivity of Muscle.—If a constant battery current is allowed to flow through a muscle, it acts upon it as it does upon the nerve, and puts it into the peculiar condition called by DuBois-Reymond "electrotonus," in which its irritability and conductivity are markedly altered.

If a battery current is sent for a short time through a curarized sartorius muscle, from end to end, and the muscle is then irritated by an induction current having the same direction, applied to it through the same electrodes, it will be found that the irritability is increased by the flow of the current. Von Bezold ("Untersuchungen über die electrische Erregung der Nerven und Muskeln," S. 211, Leipzig, 1861), who was the first to observe this, supposed that the irritability of the whole muscle was increased. Biedermann ("Electro-Physiology," translation by Frances Welby, i., p. 291, London, 1898) has shown that this is not the case. The flow of the current first increases the irritability at the cathode if the current is weak, but decreases it if the current is strong and long-continued. The changes in irritability are not to be found in the intrapolar or extrapolar regions.

Biedermann (*loc. cit.*, p. 286) gives the following explanation of the loss of irritability seen at the cathode when the muscle is subjected to a strong current for a considerable time: An electric current during its flow raises the irritability of the muscle at the cathode, and produces latent excitation effects, which, though insufficient to cause the discharge of an excitation wave, result in fatigue and decreased irritability at the points where the current leaves the muscle fibres. The after-effect of the current is decreased irritability at the cathode and increased at the anode, these changes, too, being localized at the poles. On account of the loss of irritability produced at the cathode, a current sufficiently strong to produce a marked closing excitation, if withdrawn after flowing a short time and then sent in again, fails to give a closing excitation. If the current be then put through the muscle in the reverse direction, so that the former anode is made a cathode, a good closing contraction is obtained. This phenomenon is analogous to what is known as the "voltaic alternative" in the case of nerves.

The conductivity is altered in the same way as in nerves. Contrary to the view of von Bezold, it is not changed in the intrapolar region. Engelmann (Pflüger's *Archiv*, iii., 1870), studying the ureter of the rabbit, found that the conductivity is lessened at the anode by medium currents and is lost there by strong currents. Further, by strong, continued currents, the conductivity decreases at the cathode. Biedermann (*loc. cit.*, 296) associated this with the lessened irritability and regards it as an effect of the fatigue caused by the latent excitation. He did not find it less at the anode in the case of striated muscles, but as it is lessened at the anode in the case of the nerves and non-striated muscle, he thinks there must have been some experimental error.

Polar Excitation of Muscle by the Battery Current.—In the case of muscles as of nerves, the excitation process develops at the cathode on the closing and at the anode on the opening of the current.

Both Vulpian (*Gaz. méd. d. Paris*, p. 618, 1857; Compt. rend. (2), iv., 1857; *Journ. de Physiol.*, i., p. 569, 1858) and Schiff (Molesch. "Unters.," v., S. 187, 1858; "Beiträge z. Physiol.," ii., S. 13) observed that when a muscle is dying and can no longer transmit the excitation wave, it may show a localized contraction, an "idiomuscular welt," at the point of application of the cathode. They failed to recognize the significance of the phenomenon, and we are indebted to von Bezold for the proof that the "law of contraction" found by Pflüger and Chauveau for nerves holds good for muscles. He connected a myograph lever with the tibial end of a curarized sartorius muscle, and then recorded the latent period of the muscle when the upper part was held firmly by two electrodes placed at unequal distances from the tibial end. The latent period was longer by closing excitations when the cathode was farther away from, and shorter when it was nearer to, the recording part of the muscle.

Engelmann (Pflüger's *Archiv*, iii., S. 247, 1870) reported that the ureter of the rabbit exhibits in an admirable manner the polar effects of the current, a peristaltic contraction wave starting from the cathode on the closing and from the anode on the opening of the current. Hermann ("Handbuch der Physiol.," Bd. ii., Abth. 1, S. 93, 1879) states that if loops of wet thread be used as electrodes and placed on the curarized muscle, a welt-like contraction develops at the cathode on the closing, and at the anode on the opening, and draws the whole muscle toward the electrode in question. Engelmann (Pflüger's *Archiv*, xxvi., S. 97) and Biedermann ("Sitzungsbr. d. k. Akad. d. Wiss. z. Wien," Bd. lxxx., Abth. 3, S. 367) ascertained that if a part of a muscle be injured by being dipped into a hot salt solution, and electrodes be applied, the one to the injured the other to the normal part, the closing contraction is very feeble if the cathode be applied to the injured part, but vigorous if it be applied to the normal part. These and many other similar observations have fully established von Bezold's conclusions.

Not only does the muscle contract when the current is made or broken, but during the flow of the current a continuous slight contraction may be observed at the cathode. If a current be led through a muscle from end to end, one can see with a lens a swelling of the muscle at the point where the current leaves it. The difference between the two kinds of contraction is well brought out in the following experiment of Engelmann (Pflüger's *Archiv*, iii., S. 316): He clamped a curarized sartorius muscle in the middle, applying the clamp firmly enough to prevent the muscle from moving but not enough to interfere with its conductivity; he then placed the electrodes near the two ends, and connected the tibial end with a recording lever When the anode was on the writing end, a single twitch was seen on the closure of the current; when the cathode was on that end, the twitch caused by the closing of the current was followed by a prolonged contraction. The tendency of the muscle to give a prolonged localized contraction at the cathode during the flow of the current is increased by cold or any influence which slows muscular reactions.

In conclusion it may be said that the battery current can arouse two different kinds of contraction in the muscle; a sudden change in the intensity of the current at the instant it is closed or opened causing a simple twitch, and a continuous flow of the current causing a prolonged tetanic contraction. When the current is closed the excitation develops at the cathode, and when it is opened at the anode, and it is probable that in the case of the muscle as of the nerve the excitation processes are associated with the sudden passage of the tissue into a state of catelectrotonus and out of a state of anelectrotonus. In a like manner we can compare the continuous contraction which is developed in the muscle at the cathode when the flow of the current is prolonged, with the continued state of heightened irritability which exists in the nerve while it is subjected to the flow of the current. As Gotch (Schaefer's "Textbook of Physiology," ii., p. 436) says: "In the muscle, contraction is the sign of the cathodic state; in the nerve, increased excitability."

There is another interesting effect which may be mentioned in this connection, viz.: the inhibitory action of the anode during the flow, and of the cathode on the opening of the current. Biedermann ("Electro-Physiology," trans., i., p. 257, 1896) states that if the electrodes are applied to the ventricle of the heart, the muscle relaxes during systole at the point of application of the anode when the current is closed, and at the point of application of the cathode when it is opened. A stronger current is required for the cathodic than for the anodic effect.

The inhibitory influence of the anode can be well seen if a battery current is allowed to flow through a piece of smooth muscle when in tonic contraction (Biedermann, *loc. cit.*, p. 256). It is also observed on striated muscles, when put into a state of tonus by veratrine. The phenomenon is undoubtedly associated with the decrease of irritation which takes place at the anode on the closure and at the cathode on the opening of the current (Biedermann, *loc. cit.*, p. 265).

Electrotonic Currents.—If a constant current be sent through a special part of a nerve, and a galvanometer be connected with any portion of the nerve, either central or peripheral to the region subjected to the polarizing current, the instrument will indicate the presence of an electric current having the same direction as the battery current. The battery current through which these changes are produced is frequently spoken of as the polarizing current, and the electrodes connecting the battery with the nerve as the "polarizing electrodes." The electrodes which connect the nerve with the galvanometer, or electrometer, when the electrotonic currents are being studied, are referred to as the "leading-off electrodes."

The fact that the flow of a constant battery current through a part of a nerve can alter the electromotive state of the whole nerve was first observed by DuBois-Reymond ("Untersuchungen über thierische Electricität," Bd. ii., Abth. 1, S. 289, 1849), who called the electric currents which result from the change "electrotonic currents," those to be obtained from the side of the anode being termed "anelectrotonic," and from the side of the cathode "catelectrotonic" currents (see Fig. 1851).

I. The anelectrotonic current strengthens the effect of the demarcation current on the galvanometer.

II. The catelectrotonic current weakens the effect of the demarcation current on the galvanometer.

This can be taken as a proof that electrotonic currents are independent of the current of rest. Another proof is that they can be observed when, on account of the symmetrical arrangement of the leading-off electrodes, demarcation currents cannot be detected. With this arrangement a change in the electrical condition of the nerve is caused by the polarizing current, of such a type that all points of the nerve on the side of the cathode are more negative and all points on the side of the anode more positive than normally, the change being greater close to the electrodes, and shading off from these points in both directions along the nerve. This is true of the extrapolar regions at least, and probably is true of the intrapolar region also, though considerable uncertainty exists as to just what happens in this part. To state the change with reference to the direction of the polarizing current, a battery current flowing through a portion of a nerve alters the chemical condition of the whole nerve, all points of which become electrically active in the direction of the current, each point becoming galvanometrically negative in respect to other points in advance of it in the direction of the current.

If one would avoid confusion in studying this subject, he must always bear in mind the fact that a current is always to be considered as flowing in a circuit, from the positive to the negative sign, and consequently the flow in the part of the circuit containing the nerve must have the opposite direction to the flow in the part containing the galvanometer. A point which is positive with reference to the direction of flow through the galvanometer is negative with reference to the direction of flow through the nerve, and *vice versa.*

Electrotonic currents are not to be identified with currents of action, because they are to be seen when the battery current is flowing constantly through a motor nerve, and is too weak to cause a state of excitation, sufficient at least to produce a current of action and a contraction of the muscle. Further, as Hermann ("Handbuch d. Physiol.," Bd. ii., Abth. 1, S. 158, 1879) says, the fact that electrotonic currents increase with increase of strength of the polarizing current, and do not reach a maximum, is against the view that they are the result of a condition of excitation. Finally, the electrotonic effects are the stronger the nearer the part of the nerve examined to the region through which the battery current is flowing, which would not be true of currents of action.

To any one familiar with the tendency of electrical currents to spread through moist conductors, the first thought is, that electrotonic currents are due to the ordinary spread of the battery current beyond the electrode bringing it to the nerve. That this is not the immediate cause is proved by the fact that whatever interrupts the physiological conductivity of the nerve, as a ligature or strong acid applied between the polarizing electrodes and leading-off electrodes, although not lessening the physical power of the nerve to conduct electric currents, often wholly does away with the phenomenon. The same is true of anything which will lessen the physiological activities of the nerve. DuBois-Reymond failed to find electrotonic currents on dead nerves, moist threads, and muscles, which offer favorable conditions for the spread of electrical currents. Schiff ("Lehrbuch d. Muskel u. Nervenphysiologie," S. 69, Larr, 1858–59) and Valentine (*Zeitschrift. f. rat. Med.* (3), xi., S. 1, 1861) failed to find them on degenerated nerves, while Gruenhagen

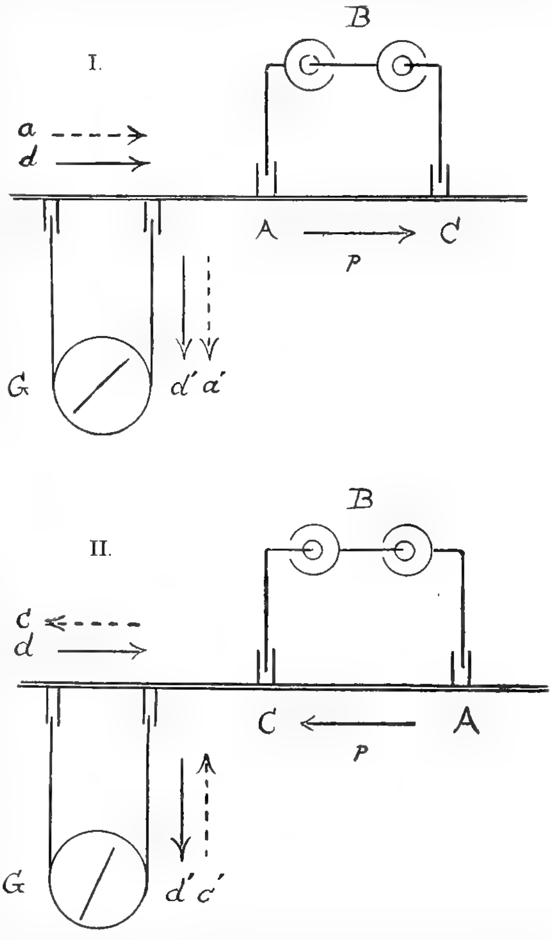

FIG. 1851.—Effect of Electrotonic Currents on the Demarcation Current. *B*, Battery; *A*, positive electrode, the anode; *C*, negative electrode, the cathode; *G*, galvanometer; arrow *p* shows the direction of the polarizing current; arrow *d* shows the direction of the demarcation current in the nerve; arrow *d′* shows the direction of this current in the galvanometer circuit; arrow *a* shows the direction of the anelectrotonic current in the nerve; arrow *a′* the direction of this current in the galvanometer circuit; arrow *c*, the direction of the catelectrotonic current in the nerve; arrow *c′*, the direction of this current in the galvanometer circuit.

(*Königsberger med. Jahrb.*, iv., S. 199, 1864) thinks that he observed them. Boruttau (Pflüger's *Archiv*, Bd. lviii., S. 29, 1894) observed electrotonic currents on the nerves of frogs ten or twelve days after their removal from the body, and long after they had lost the power to excite the muscles. As long as the ordinary structure of the nerve is retained, these currents can be detected; but they weaken the more the chemico-physical condition departs from the normal. Hermann ("Handbuch d. Physiol.," Bd. ii., Abth. 1, S. 158) draws attention to the fact that electrotonic currents have been found to be greater in frog's nerves, at the side of the anode than at the side of the cathode, though if due to the ordinary spread of current it is likely that they would be the same.

Probably, under certain conditions, feeble currents which are of purely physical origin may be detected in the extrapolar regions; these are not to be confused with physiological electrotonic currents, although these, too, as we shall see, are in their ultimate analysis the result of chemico-physical changes brought about in the living substance by the polarizing current. Waller ("Lectures on Animal Electricity," p. 104, London, 1897) discusses this question, and shows how by the use of anæsthetics, ether and chloroform, one can distinguish between the purely physical and physiological factors of the phenomenon. He finds that the physiological factor, the true anelectrotonic and catelectrotonic effects, disappears as the physico-chemical conditions peculiar to the living state are suppressed by the anæsthetic, and the physical factor, the "physical electrotonus" of certain German monographs, the "residual deflection" as he calls it, remains. Physical electrotonus, according to Waller, means nothing more than current escape (see (Waller, "Lectures on Animal Electricity," note, p. 106). Biedermann ("Sitzungsbr. d. k. Akad. d. Wissensch.," Bd. xcvii., Abth. 3, S. 84, Wien, 1888; "Elektro-Physiology," translated by Frances C. Welby, ii., S. 294, London, 1898) was the first to use an anæsthetic to distinguish between physiological and physical electrotonic effects. His conclusions, as we shall see later, differed from those of Waller (see effect of anæsthetics, p. 775).

The effect of the temperature is another proof that true electrotonic currents are dependent on the normal physiological condition of the nerve. Raising the temperature to 40° C. (which would be favorable to the physical conduction of the current), or lowering it to 5° C., causes the extrapolar currents to disappear (Waller, *loc. cit.*, p. 107).

Strength of Electrotonic Currents.—Electrotonic currents are the stronger the greater the intensity of the polarizing current, within the limits which would cause injury of the nerve; the longer the stretch of nerve subjected to the current, provided the resistance be allowed for; the nearer the leading-off electrodes are placed to the polarizing electrodes; the more normal the condition of the nerve, and the greater the polarizability of the nerve. A maximum strength of electrotonic current has not been found. Anelectrotonic currents are stronger than catelectrotonic, and DuBois-Reymond (*Archiv f. Anat. u. Physiol.*, S. 441, 1867) obtained anelectrotonic currents twenty-two times the strength of the demarcation current, and requiring an electromotive force of 0.5 of a Daniel cell for their compensation.

Secondary Electrotonus.—The strength of the electrotonic current developed in a nerve may be enough to excite another nerve in contact with it. The current in the first nerve flows through the second, which completes the circuit for it; when the current enters or ceases to flow through the second nerve, on the make and break of the polarizing current in the first nerve, the second nerve is excited and a muscle connected with it will contract. For example, exciting the central stump of the peroneal may excite the fibres of the tibial, where they run by the side of the peroneal fibres in the sciatic, and may cause a contraction of the gastrocnemius. This "paradoxical contraction" of DuBois-Reymond ("Untersuch.," ii., 1, S. 528, 1849) is not to be confused with the "paradoxical contraction" of Hering (Hermann's "Handbuch," Bd. ii., Abthl. 1, S. 160, 1879), due to excitation of a second nerve by the current of action of the first. The electrotonic current from the first nerve can put the second into secondary electrotonus, as can be shown with a galvanometer; and Moleschott ("Untersuch.," Bd. x., S. 649, 1870) has seen even a tertiary electrotonus.

Rate of Development and Spread of Electrotonus in Nerves.—DuBois-Reymond ("Untersuch.," Bd. ii., S. 321, 391, 540, 1849) concluded that electrotonus begins to develop at the two poles at the instant the polarizing current is closed. Pflüger ("Untersuch. u. d. Physiol. d. Electrotonus," S. 442–444, 1859, Berlin) agrees with this; he writes: "DuBois-Reymond has shown that the growth of the electrotonic current finds sufficient time for its development even by the quickest induction currents. I can affirm the same for the rate at which, with strong currents, the change of irritability occurs after the closing of polarizing currents." Helmholtz ("Monatsberichte d. Berliner Akad.," S. 329, 1854), making use of DuBois-Reymond's "paradoxical contraction," *i.e.*, letting the electrotonic current of one nerve excite another nerve resting upon it, concluded that "the condition of electrotonus does not appear demonstrably later than the electrotonic current which excites it." Bernstein ("Naturwiss. Rundsch.," S. 9, 1887; "Untersuch. a. d. physiol. Inst. d. Univers. z. Haller," S. 75, 1888) ascertained, with the aid of his rheotome, that extrapolar electrotonus shows itself near the poles within 0.001 second after the battery current has been closed, and Hermann (Pflüger's *Archiv*, lxii., S. 1, 1888) concluded that the polarization changes causing these currents begin at the instant that the polarizing current enters the nerve.

The method of the rise and fall of the electrotonic change was first described by DuBois Reymond (*Archiv f. Anat. u. Physiol. u. wissensch. Med.*, S. 446, 1867), who found that anelectrotonic currents of nerves grow to their maximum somewhat less rapidly than catelectrotonic, and then gradually fall, while catelectrotonic currents reach their maximum almost immediately and then forthwith fall, the decline occurring even during the rise of the anelectrotonic currents.

It is generally conceded that electrotonus begins to develop at the poles at the instant the current is closed, and spreads thence along the nerve in the form of a wave; great differences of opinion exist, however, as to the rate at which it travels along the nerve. Pflüger ("Electrotonus," S. 442) decided that anelectrotonic alterations of excitability occur at the same instant as the anelectrotonic currents, and he considered that those two phenomena were merely different expressions of the change produced in the nerve by the polarizing current. This makes the rate of spread of the change of irritability of interest in this connection. Gruenhagen (Pflüger's *Archiv*, iv., S. 549, 1871; vi., S. 181, 1872) found that the changes in irritability associated with anelectrotonus and catelectrotonus are transmitted with equal rapidity, and appear in all parts of the nerve at the instant that the current is closed. Wundt ("Untersuch. z. Mechanik. d. Nerven u. Nervencentren," i., 1871) arrived at a different result, deciding that the alterations of irritability of the nerve of the frog do not develop in all parts of the nerve at the instant of the closure of the current, but spread over the nerve as a comparatively slow, wave-like process, comparable to the excitation wave, "the anodic wave of inhibition" travelling at the rate of 80–700 mm. per second, according to the strength of the current. Baranowsky and Garre (Pflüger's *Archiv*, xxi., S. 446, 1880) got rates which were entirely different from those of Wundt, and which were favorable to Gruenhagen's conclusions. They found that the decrease of excitability in the anodic extrapolar regions must spread at a rate of not less than 165 metres per second. Ascher (*Zeitsch. f. Biol.*, xxxii., S. 473, 1895), on the other hand, concluded the rate of propagation to be 30 metres per second.

Experiments on the rate of transmission of electrotonic currents both in the nerve and in "core-conductor models" of nerves, have given equally contradictory results. DuBois-Reymond (*Archiv f. Anat u. Physiol.*, S. 449, 1867; Ges. Abthl., S. 258), reviewing Helmholtz's experiment, cited above, decided that it showed that the changes in the nerve which underlie electrotonus are transmitted as rapidly as the excitation process. Tschirjew (*Archiv f. Anat. u. Physiol.*, S. 525, 1879) concluded that the rate was about the same, or perhaps slightly slower than the excitation process; and Bernstein (*Archiv f. Anat. u. Physiol.*, S. 197, 1886) found that the propagation of electrotonic changes is less rapid than that of the excitation wave, the catelectrotonic wave travelling at the rate of 9–10 mm. per second. Lately, Hermann and Weiss (Pflüger's *Archiv*, lxxi., S. 237, 1898) have expressed themselves in favor of Gruenhagen's view, that the electrotonic state develops in all parts of the extrapolar regions of nerves instantaneously.

Experiments on "core-conductor models" (see page 777) are of great interest in this connection, for the results obtainable with them imitate with wonderful accuracy the phenomena observed on nerves. Boruttau (Pflüger's *Archiv*, lviii., S. 1, 1894) finds on his core-conductor models of nerves what DuBois-Reymond found for nerves themselves, viz., that catelectrotonus develops faster and declines more rapidly than anelectrotonus. A study of the galvanic alterations in these models, under the influence of a polarizing current, shows the extrapolar electrotonic currents to be transmitted in the form of a wave, the rate varying with the composition of the model, the temperature, etc., and averaging about 100 metres per second. Hermann and Samway (Pflüger's *Archiv*, xxxv., S. 1, 1884) had found the rate to be at least 60 metres per second. Gotch and Burch (Schaefer's "Textbook of Physiol.," ii., p. 549, 1900), employing capillary electrometres and recording the movements of the mercury by photography, found the rate on models to be over 100 metres per second.

An explanation of the conflicting results which have been obtained by those who have studied this question may be found in the way in which electrotonic currents in nerves and core conductors develop and decline, and in the fact that they lessen in intensity as the distance from the poles increases. Hermann (Pflüger's *Archiv*, xvi., S. 423, 1880; Hermann and Weiss, Pflüger's *Archiv*, lxxi., S. 237, 1898) points out that a difference in the strength of the current at the different parts of the nerve might well result in a difference in the lag of the recording instrument. Both Biedermann ("Electro-Physiol.," ii., S. 280, 1895) and Gotch (Schaefer's "Textbook of Physiol.," ii., pp. 497 and 549, 1900) in their reviews of this subject agree that all the slower times which have been given are for this reason open to suspicion. On the whole the evidence is in favor of the view that the electrotonic changes spread to all parts of the nerve almost instantaneously.

Electrotonus in Non-Medullated Nerves.—It was for a long time generally believed that the electrical phenomena, at least, of electrotonus occurred only in medullated nerves and were absent from non-medullated nerves. This difference was attributed to the peculiar structure of the medullated nerve, an axis cylinder surrounded by a sheath of different chemical composition.

It has been shown by Biedermann ("Bericht. d. Wien. Acad. d. Wiss.," Bd. xciii., Abth. 3; Bd. cxvii., Abth. 3; Pflüger's *Archiv*, liv., S. 24; "Electrophysiology," ii., p. 281, 1895) that certain electrotonic effects may be observed on the non-medullated nerves of a mollusk, the Anodonta. If such a nerve be connected by its longitudinal surface and cross section with a galvanometer, it shows a strong demarcation current; if this be compensated, and a battery current be applied to a distant part of the nerve, there is at the instant of closure a swing of the galvanometer in a direction corresponding to a negative variation of the demarcation current, this being due to the action of the current resulting from excitation. If the polarizing current passes through a part of the nerve not far from the leading-off electrodes, the negative variation is followed by a positive variation when the polarizing current is ascending (flowing away from the leading-off electrodes), *i.e.*, when the anode is nearest to the leading-off electrodes. If the negative effect was large, the positive after-effect is delayed and increases more slowly during the passage of the current. Its maximum strength comes with a greater intensity of battery current than is required to produce the maximum of the initial negative variation. Of course these two influences antagonize each other, and produce more or less conflicting results, according to their relative strength. This anelectrotonic effect is greater the stronger the polarizing current, the nearer the leading-off electrode to the anode, and the greater the vitality of the nerve. When the polarizing current is descending, *i.e.*, when the cathode is nearest the leading-off electrodes, little or no increase in the effect of the current of action on the galvanometer is seen.

It would appear from these results of Biedermann that non-medullated, like medullated nerves show anelectrotonic galvanic effects, but that they fail to show catelectrotonic effects. von Uexhuell (*Zeit. f. Biol.*, x., S. 550) failed to find any marked electrotonic effects on the non-medullated nerves of cephalopods; but Boruttau (Pflüger's *Archiv*, lxvi., S. 285, 1897; *ibid.*, lxviii., S. 351, 1897; lxxxiv., S. 378, 1901) reports that these nerves show the same electrotonic changes as medullated, except that catelectrotonic effects are feeble, and the anelectrotonic condition may extend over into the cathodic area. Mendelsohn (*Bul. de la Soc. de Biol.*, 1900; Richet's Dictionnaire de Physiologie, v., p. 414, 1901) also, as a result of work on many different forms, asserts that in general the non-medullated nerves of lower animals present the same qualitative electrotonic manifestations as the medullated nerves of the higher animals. Quantitatively, however, there are great differences; catelectrotonic changes are always less pronounced than anelectrotonic changes in non-medullated nerves (in some forms, indeed, may be absent), and very much less marked than in medullated nerves. It is to be remembered that the medullated nerves of higher animals differ in regard to the strength of anelectrotonic and catelectrotonic effects. In frog's nerves anelectrotonus is usually stronger than catelectrotonus, while in mammalian nerves, according to Waller ("Lectures on Animal Electricity," p. 97, and p. 122, 1897), they are of equal importance. Boruttau finds (Pflüger's *Archiv*, lxxxiv., S. 380, 1901) that in mammalian nerves anelectrotonic effects are always somewhat more than catelectrotonic, though the difference is considerably less than in the case of the nerves of frogs.

Influences which Alter the Physiological Activity of the Nerve Alter the Electrotonic Currents.—The death of a nerve, however produced, does away with electrotonic currents, and conditions which merely modify the physiological activity of the nerve alter the intensity of these phenomena.

Effect of Anæsthetics.—Biedermann ("Elektrophysiologie," S. 696, Jena, 1895; Sitzungsbr. d. k. Akad. d. Wissensch., Bd. xcvii., Abth. 3, S. 84, Wien, 1888) observed that if a nerve were etherized, although the irritability and conductivity were lost, electrotonic effects were still to be observed. Normally, anelectrotonic effects are considerably in excess of catelectrotonic, but after etherization they are about the same. Biedermann attributed the electrotonic effects which remained after etherization to the electrolytic effects of the current, and concluded that they were purely physical phenomena, while those which were lost he considered to be the true physiological electrotonic changes. He regarded the physiological factor to be the result of a reaction of the nerve, dependent on increased assimilation in Hering's sense, and to correspond to greater functional activity.

Waller ("Lectures on Animal Electricity," p. 104, London, 1897) also made use of anæsthetics to distinguish between the physical and physiological elements of electrotonus, but arrived at different results. He found (Proc. Physiol. Soc., *Journ. of Physiol.*, vol. xix., 1896) that both the anodic and cathodic effects, and their diminution on excitation of the nerve, are influenced by all the agencies which alter the electrical response of the nerve. Ether, chloroform, and carbon-dioxide gas may abolish both anelectrotonic and catelectrotonic effects, the abolition being succeeded by secondary augmentation. This result is in favor of the view that the total electrotonic effect is physiological, if we except the minor effects of current escape which may occur when very strong polarizing currents are employed. A similar conclusion is reached by Boruttau (Pflüger's *Archiv*, lxxxiv., S. 381, 1901); Waller also found that electrotonic currents may be temporarily modified by narcotics in such a way that the catelectrotonic effect may be relatively strengthened and the anelectrotonic current weakened, so that the quotient $\frac{A}{K}$ may be less than one. This has been corroborated by Boruttau (Pflüger's *Archiv*, lxxxiv., S. 335, 1901).

Effect of Acids and Bases.—This question is of importance with reference to the electrolytic changes which the current produces in the nerve. Waller ("Lectures on Animal Electricity," p. 125, 1897) studied the effects of weak acid and alkaline baths, and carbon-dioxide gas and the fumes of ammonia, upon anelectrotonus and catelectrotonus. He found catelectrotonus to be increased by slight acidification and decreased by slight basification; anelectrotonus, on the other hand, is generally decreased by slight acidification and but little affected by slight basification. To state the effects in the order of their occurrence with respect to the strength of the acid, first there is increase of anelectrotonus; second, diminished anelectrotonus and increased catelectrotonus, this being the typical effect; third, diminished catelectrotonus, as the last effect. These effects come out clearly only when the strength of the acid is nicely graded, as otherwise the finer effects are lost. The relation of anelectrotonus to catelectrotonus under these influences can be expressed by the quotient $\frac{A}{K}$. Generally the early stages are lost, and by acidification both A and K are lessened; but A is lessened more than K, so the total effect is to lessen $\frac{A}{K}$ by acidification. The characteristic effect by basification is to increase $\frac{A}{K}$. The effect of tetanizing the nerve is, according to Waller, the same as the effect of carbon-dioxide gas upon the nerve, and he argues that the effect during tetanization is due to the production of carbon-dioxide gas by the active nerve tissue, a view which Boruttau is inclined to favor.

Effect of Temperature.—According to Biedermann ("Elektrophysiol.," S. 690, 1895), if the nerves of frogs are cooled, they appear to approach the state of non-medullated nerves in their electrotonic reactions, the ordinary difference between the strength of the anelectrotonic and catelectrotonic effects being accentuated, because the cold enhances the physiological anelectrotonic reaction. Waller, however, has seen both anelectrotonus and catelectrotonus disappear under the effect of temperatures of 40° C. and 0° C. If the exposure to the abnormal temperature was not too prolonged, electrotonic currents were again seen on the return of the temperature to 15° C. The effect of lowering the temperature to normal after heating to 40° C. was to cause the catelectrotonic currents to be greatly increased, so as to be even more than the anelectrotonic. This fact is attributed to the chemical disruption of the living matter under the influence of the heat, the effect being the same as that produced by acid and by tetanization of the nerve.

Effect of Excitation on Electrotonus and the Effect of Electrotonus on the Current of Action.—Bernstein (*Archiv f. Anat. u. Physiol. u. wissensch. Med.*, S. 614, 1866) was the first to study this question. He found that the current of action causes a negative variation of electrotonic currents, similar to that which it produces in demarcation currents. This change is known as the "electrotonic decrement" of Bernstein. The view was advanced that the excitation process lessened the susceptibility of the nerve to polarization. Hermann ("Handb.," Bd. ii., Abth. 1, S. 165, 1879) corroborated the fact but gave another explanation. His view, which has since been generally accepted, is that the electrotonic currents are peculiar threads of currents from the polarizing circuits, and that the apparent negative variation of the same is due to a change caused by the excitation process in its passage through the polarized nerve. He explains the facts on the assumption that the wave of negativity which accompanies the irritation-process gains intensity as it spreads toward more strongly anelectrotonic or more weakly catelectrotonic parts of the nerve, and loses intensity as it spreads toward more weakly anelectrotonic or more strongly catelectrotonic parts of the nerve (law of the polarization increment of irritation). According to this view, the irritation process would be at its maximum at the anode and at its minimum at the cathode, *i.e.*, the galvanometer would indicate a marked negativity in the region of the anode as compared with the cathode, which would mean that there would be in the intrapolar region a strong axial current of action of the same direction as the polarizing battery current, which would make it appear that this was strengthened. This is in fact observed in galvanometer experiments, and was explained by Gruenhagen as due to a lessening of the resistance during excitation. Hermann found, however, that this does not happen, and that the effect is, as has been stated, the result of an electro-motive force resulting from the excitation. The current of action, then, because of the same direction as the polarizing current, makes it appear that this is strengthened; on the other hand, because of the opposite direction to the polarization current, it makes it appear that the polarization is less.

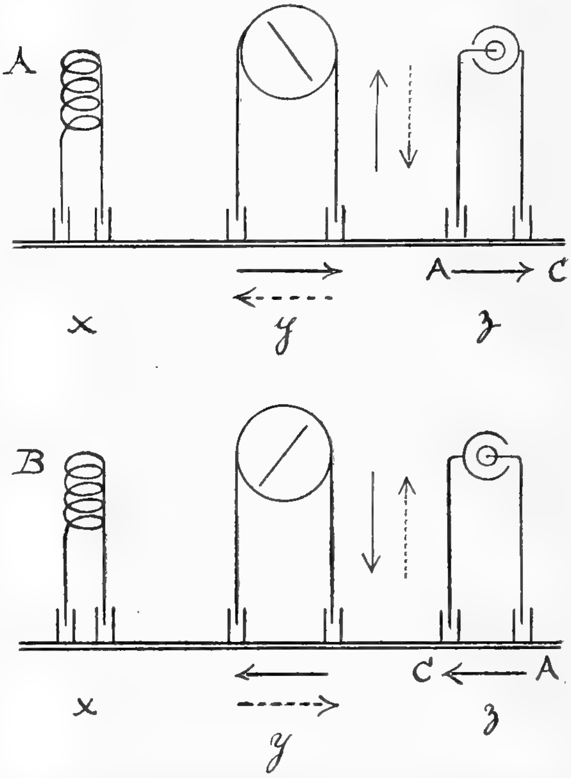

FIG. 1852.—*A*, Showing Lessening of Anelectrotonic Current. *B*, Showing Lessening of Catelectrotonic Current. *X*, Exciting circuit; *Y*, galvanometer circuit; *Z*, polarizing circuit; black arrow, direction of electrotonic currents; dotted arrow, direction of electromotive effect due to excitation.

In the extrapolar regions there is a decrease of the electrotonic currents, both on the side of the anode and on that of the cathode. If, for example, the galvanometer circuit is between the part excited and the part subjected to the polarizing current, the effect of the anodic electrotonic current on the galvanometer will be lessened when the excitation is given, because the part of the nerve near the anode will become more negative than more distant parts, and the effect of the cathodic electrotonic current on the galvanometer will be lessened because the part of the nerve near the cathode will become less negative than more distant parts.

Similar effects are observed when the galvanometer electrodes are connected, the one with the cut end and the other with the longitudinal surface, only in this case the presence of the demarcation current complicates the result. The current of action undergoes a marked alteration in its passage through the polarized region, the wave of negativity increasing as it approaches parts relatively more positive (as the region of the anode), or leaves parts relatively more negative (as the region of the cathode), and decreasing as it approaches more negative, and leaves more positive parts of the nerve. These effects are best observed with a capillary electrometer (Gotch and Burch, Proc. of Roy. Soc. London, vol lxiii., p. 300, 1898; Schaefer's "Textbook of Physiol.," vol. ii., p. 552, 1900). Boruttau (Pflüger's *Archiv,* lxxxiv., S. 334, 1901) says, if the part of the nerve connected with the electrometer is between the point irritated and the part of the nerve subjected to the battery current, when the anode is nearest, the second phase of the current of action is strengthened, and when the cathode is nearest it is weakened; while the first phase, if superposition be allowed for, is lessened in the first case, and generally increased in the second, although here, too, it may be lessened. Just the opposite happens when the region subjected to the battery current is between the part irritated and the portion connected with the electrometer. If with this arrangement the electrometer electrodes connect the longitudinal surface with a cross section, the single phase of the current of action is lessened if the anode is nearest, and strengthened if the cathode is nearest, as Bernstein found (1866) for the negative variation caused by excitation of the nerve with an interrupted current.

The After-Effects of Polarization, Secondary Electromotive Phenomena.—When a strong polarizing current is withdrawn from a nerve, two different phenomena present themselves. On account of the electrolytic effects produced in the nerve by the polarizing current, polarization currents of opposite directions to the battery current are present after its removal. On account of alterations in irritability of the tissue, excitation effects may not only occur at the instant of the removal, but they may continue for some time after. The effect of the condition of excitation is to make the former anode negative as compared with the rest of the nerve, from the standpoint of the galvanometer circuit, which means that within the nerve currents would flow away from this point. These internal currents of action would have the opposite direction to the polarization current, and in the anodic extrapolar region tend to nullify its action on the galvanometer. The result is that the anodic polarization changes are overpowered, and the cathodic extrapolar currents alone manifest themselves. This interpretation is in harmony with the results observed in muscle after the removal of the battery current.

Electrotonic Currents of Muscle upon Removal of the Battery Current.—Muscles if subjected to the flow of a battery current become polarized just as the nerves do, the electrotonic effects differing only in respect to intensity. DuBois-Reymond ("Untersuch.," Bd. ii., Abth. 1, S. 329, 1849) was the first to observe polarization currents in muscle and termed them "secondary currents." Valentin (Pflüger's *Archiv,* i., S. 512, 1868) reported that muscles might show extrapolar electrotonic currents, and Hermann ("Handbuch d. Physiol.," Bd. i., Abth. 1, S. 91–93; Bd. ii., Abth. 1, S. 168, 1879) confirmed this result. The effects are most marked in the immediate vicinity of the electrodes, and as in the case of nerve are strongest near the anode. DuBois-Reymond observed two opposite effects on removing the battery current, the one indicating a polarization current of the same, and the other of the opposite direction to the polarizing current. The former of these (which he called the positive polarization current) is a current of action, due to a condition of excitation developed at the region of the anode, which becomes suddenly relatively negative at the instant that the battery current is broken. That this current is the result of the opening excitation is shown by the following facts, viz.: it can be observed best by placing one electrode at the anode and the other at a short distance from this, the electrode at the anode becoming negative in relation to the other; it is best developed when the battery current is strong, of short duration and rapidly broken; the effect is only to be observed on fresh muscles. Later writers have generally employed the term "anodic after-effect" for this change.

The polarization currents which have the opposite direction to the battery current, the negative polarization currents of DuBois-Reymond, are purely physical phenomena, such as can be obtained in any electrolyte as the result of the flow of a battery current. These polarization currents are found throughout the intrapolar region, and, although weak, in the extrapolar. They last but a short time after the withdrawal of the battery current, and their amount varies with the strength and duration of the battery current. Although physical phenomena, they are intimately related to the physical and chemical structure of the protoplasm of the muscle, for they fail if it is altered by heat, etc. Nevertheless they are not the result of the physiological activities of the muscle, because they can be obtained when the muscle is too fatigued to respond to stimuli.

Theories of Electrotonic Currents.—Two principal theories as to the origin of electrotonic currents have been evolved. The first of these, known as the "molecular theory," was set forth by DuBois-Reymond ("Untersuchungen über thierische Electricität," ii., S. 289–389, 1849). According to this, the battery current altered the position of hypothetical electromotive molecules of the nerve, giving them a columnar arrangement. We need not dwell on this conception, as the theory and its various modifications (Bernstein, Pflüger's *Archiv,* vi., S. 335, 1872; Fleischl, "Sitzungsbr. d. Wiener Akad.," Abth. 3, lxxvii., 1878) have been displaced by the theory of electrolytic polarization. Hermann discusses the earlier literature of this subject in his "Handbuch der Physiologie," Bd. ii., Abth. 1, S. 171–196, 1879.

Peltier discovered the occurrence of polarization in animal tissues, and DuBois-Reymond ("Unters. ü. thier. Electric.," i., S. 376, 1848; ii., 2, S. 377, 1849) repeated his observations, and detected after the removal of a battery current from an isolated nerve an electromotive force of opposite direction. He termed the polarization effects produced by the flow of the current "secondary electromotive effects." DuBois-Reymond also ("Monatsbr. d. Akad. z. Berlin," S. 395, 1856; Ges. Abth. 1, S. 1) reported that the polarization occurs at the bounding surfaces of dissimilar electrolytes. Matteucci (Comptes rend., l., p. 412, 1860; lii., p. 231, 1861; lvi., p. 760, 1863; lxv., p. 151, 194, 884, 1867; lxvi., p. 580, 1868), influenced by the results of Peltier and DuBois-Reymond, studied these secondary electromotive effects, and found an explanation of electrotonic currents in the internal polarization of the nerve; he also thought to have proved the existence of electrolytic products within the nerve, viz., acids at the anode and alkalies at the cathode.

Hermann ("Untersuch. z. physiol. d. Muskeln u. Nerven," Heft 3, S. 71, Berlin 1868; Pflüger's *Archiv,* v., S. 233; *ibid.,* vi., S. 312) studied the polarization after-current of the nerve, and concluded that the polarization effects are not equally distributed through the nerve, but occur at the bounding surfaces of sheath and core; that polarization explains all the galvanic effects of electrotonus; and that Pflüger's anelectrotonus and catelectrotonus correspond with the regions of positive and negative polarization of the core of the nerve.

Core-Conductor Models.—It was in 1863 that Matteucci discovered that if a constant current flows through a portion of a platinum wire covered with a sheath saturated with a fluid, extrapolar currents can be led off which correspond to the electrotonic currents of nerves. In addition, he noted that amalgamated zinc wires surrounded by a solution of zinc sulphate do not give such currents, from which he decided that electrotonic currents are the result of polarization. This view was corroborated by Schiff ("Nuovo Cimento," ave., 1868). The phenomena to be observed on core-conductor models and their relation to electrotonus in nerves were thoroughly investigated by Hermann (Pflüger's *Archiv*, v., S. 264, 1871; vi., S. 312, 1872; vii., S. 301, 1873; "Handbuch," Bd. ii., Abthl. 1, S. 174–184, 1879).

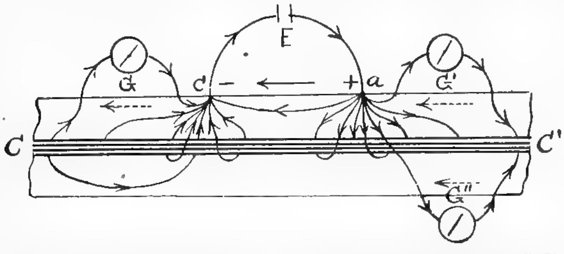

FIG. 1853.—Electrotonic Currents of a Core-Conductor Model. *C–C'*, Good conducting metal core, surrounded by fluid sheath; *E*, battery; *G*, *G'*, *G''*, galvanometers; *A*, anode; *C*, cathode of battery current; black arrow, direction of battery current; dotted arrow, direction of electrotonic current as shown by galvanometers. (Copied from Hermann's "Handbuch," Bd. ii., Abthl. i., S., 176.)

The core-conductor models employed by Hermann consisted of a platinum wire surrounded by zinc sulphate, or of an amalgamated zinc wire surrounded by zinc sulphate. The wire was passed horizontally through the middle of a glass tube containing the fluid. A number of short tubes, welded to the upper side of the main tube at stated intervals, permitted the entrance of the polarizing and leading-off electrodes, which were made of amalgamated zinc.

With this arrangement he was able to demonstrate many of the more important phenomena associated with the production of electrotonic currents in nerves. He offered the following explanation. In the case of the core conductor in which there is no polarization, such as an amalgamated zinc wire surrounded by zinc sulphate, the battery current takes the shortest path through the fluid sheath from the electrodes to the good conducting core; if, however, polarization occurs at the boundary between the sheath and the core, as happens when platinum wire is used, counter currents are set up, which resist the passage of the battery current from the sheath to the core beneath the anode, and from the core to the sheath beneath the cathode, and cause the polarizing current to spread widely along the sheath into the extrapolar regions. The current thus spreading through the moist sheath can be detected by a galvanometer connected by electrodes with the sheath in the extrapolar regions, and the current wherever tested is found to have the same direction as the polarizing current.

H. Weber (Borchardt's *Journ. f. Math.*, lxxvi., S. 1; Pflüger's *Archiv*, vii., S. 319), working with Hermann, from a mathematical research, decided that in theory metal cores are not essential to core-conductor phenomena, and that two electrolytes with polarizable contact surfaces would give like results. Hering ("Lotos. Prag.," Bd. ix., 1888) worked with models without a metal core, and therefore still more resembling nerves. He used a hollow stem of grass, soaked in water, and then filled with a strong sodium chloride solution which conducts well as compared with water. In these, too, polarization occurs at the surface of contact between the good conducting core and the less perfectly conducting sheath. Hermann says that a difference in the conduction power of core and sheath may not be essential.

Within a few years a number of papers have appeared which show an astonishing similarity in the electrical phenomena to be observed on nerves and core-conductor models. Indeed, it is claimed by some observers (Boruttau, Pflüger's *Archiv*, lviii., S. 1, 1894; lix., S. 47, 1895; lxiii., S. 158, 1896; lxviii., S. 351, 1897; Hoorweg, Pflüger's *Archiv*, lxxi., S. 128, 1898) that all the electrical phenomena which can be observed on nerves are exactly reproduced by these models. Boruttau says the form of model that most exactly imitates the electrical phenomena observed on nerves is that of Radzikowski ("Institut Solvay, Travaux de laboratoire," t. 3, fasc. 1, pp. 1–22, Brussels, 1899), which consists of a magnesium wire in dilute sodium chloride.

Electrolytic Polarization Effects.—Waller in his lectures on "Animal Electricity" argues strongly in favor of the view that extrapolar electrotonic currents are the result of electrolytic polarization, and he gives an excellent picture of the way such electrolytic changes may occur, and how they may produce the polarization currents that cause the spread of battery currents along the nerve. Gotch also (Schaefer's "Textbook of Physiol.," vol. ii., pp. 540–547, 1900) illustrates these effects well. If a battery current be sent through a fluid conductor, the current causes an electrolytic decomposition of the electrolyte and the collection of the ions at the poles. Acids, oxygen, chlorine, etc., electro-negative ions, collect at the anode, gases, hydrogen, sodium, etc., electro-positive ions, collect at the cathode.

If the current be strong, O and H may be seen to come off as bubbles. If it be weak there is still a separation of ions, though they may not be visible. The fact that such an electrolytic decomposition occurs and that the ions collect at the two poles may be detected by introducing into the solution some substance which will change color under the influence of an acid or an alkali. Waller has employed a solution of dextrin and potassium iodide to illustrate the phenomena. The battery current decomposes the iodide of potassium, the base collects at the cathode and the iodide at the anode, where it strikes a red color with the dextrin.

Gotch suggests the use of methylene blue, which is blanched on being reduced at the cathode and takes on a stronger color under the influence of the acid at the anode.

The products of the electrolytic change are themselves capable of generating a current, the anodic ions being galvanometrically positive to the cathodic ions. That they do this can be ascertained by letting a battery current flow through a moist conductor, and then disconnecting the electrodes from the battery and connecting them with a galvanometer, when a current of opposite direction to the preceding battery current will be indicated. This is the so-called polarization current.

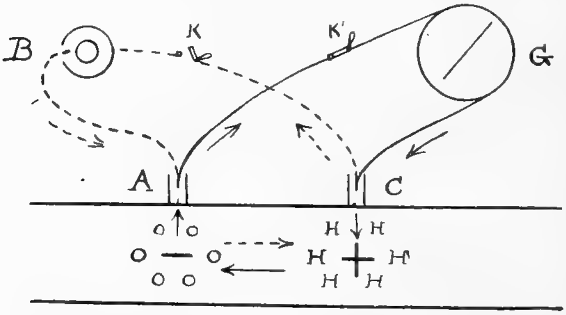

FIG. 1854.—Diagram of Polarization Currents in a Moist Conductor, when a Battery current is led through by Metal Electrodes. *A* and *C*, metal electrodes; *B*, battery; *k*, *k'*, keys; *G*, galvanometer; *O*, acid, negative, but galvanometrically positive ions; *H*, basic, positive, but galvanometrically negative ions. The dotted arrows show the direction of the polarizing current, and the black arrows the direction of polarization currents observed with galvanometer after opening of battery circuit.

This polarization change is most marked at the point where the metal electrodes come in contact with the moist conductor.

This external polarization effect may be greatly lessened by employing "non-polarizable" electrodes. In case the moist conductor is composed of more than one substance, and these have different capacities of conduction, an internal polarization may be observed. Such is especially the case with medullated nerves.

Waller ("Lectures," p. 90) shows that the human body may be internally polarized by the flow of a battery current. He took two pairs of cups containing salt solution, and connected one pair with a battery and the other with a galvanometer. He then dipped two of his fingers into the first pair of cups, thus completing the battery circuit through himself; he then removed those fingers, and dipped two others into the cups connected with the galvanometer; this showed a deflection, proving that there had been an internal polarization of his body.

DuBois-Reymond showed that the electrolytic polarization occurs at the interspace, *i.e.*, the point of contact, of the different moist conductors. This is illustrated in the following scheme (Fig. 1855).

In this case, the electrolytic effects are supposed to occur at the contact of the surfaces of the sheath and core.

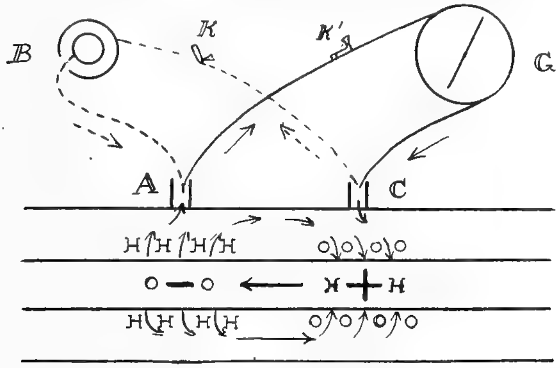

FIG. 1855.—Diagram showing the Internal Polarization Effects left in a Core Conductor, such as a Nerve, after the withdrawal of the Polarizing Current. *B*, battery; *A* and *C*, non-polarizable electrodes; *k*, *k′*, keys; *G*, galvanometer; dotted arrows, show course of polarizing current; black arrows show course of polarization currents in axis and sheath, as indicated by the galvanometer after opening of battery circuit.

We have to consider that internal anodes exist where the battery current enters the axis cylinder beneath the anode, *A*, and where it enters the sheath beneath the cathode, *C*, and internal cathodes where the current leaves the sheath below the anode, and where it leaves the axis cylinder beneath the cathode.

Negative, acid ions would collect at the internal anodes, and positive, basic ions at the internal cathodes, and these would cause the polarization currents in the axis and sheath indicated in the diagram. When the battery circuit is broken and the galvanometer circuit closed, a part of these currents will flow through the galvanometer, and the region of the anode will be found to be galvanometrically positive with reference to the region of the cathode.

Cause of Extrapolar Electrotonic Currents.—(a) After the Polarizing Current is Withdrawn. The electrolytic polarization effects are the most marked directly beneath the anode and cathode. When the battery current ceases to flow, the sheath of nerve beneath the anode will be galvanometrically positive to all other parts of the sheath, and therefore polarization currents will flow from this part of the sheath to the other less positive, extrapolar as well as intrapolar parts of the sheath, and return currents will come back to the anode through the core. If two points of the extrapolar region be connected with the galvanometer, a part of these extrapolar currents will flow through the galvanometer circuit from the point nearest the anode to the one more distant, these threads of current returning to the anode through the core. In a like manner, since the part of the sheath near the cathode is more negative than other parts of the sheath, if two points of the cathodic extrapolar region be connected with a galvanometer, current threads will be obtained flowing from more distant parts toward the cathode, and indicating a flow of current in the core away from the cathode. As a matter of fact the thickness of the sheath of a core conductor has an important influence, but this question need not be discussed here (Gotch, Schaefer's "Textbook of Physiology," vol. ii., p. 544, 1900).

(*b*) *During the Flow of the Polarizing Current.* The conditions which lead to the production of the extrapolar currents which are detected in a core conductor and nerve after the polarizing current has been withdrawn are present during the flow of the polarizing current. Electrolytic polarization effects begin to develop at the instant the polarizing current enters, and continue throughout its flow. They are, therefore, one of the sources of the electrotonic currents observed in core conductors and nerves during the flow of the current (Gotch, Schaefer's "Textbook," p. 546). Another cause is to be found in the fact that the polarization currents which develop about the core resist the passage of the battery current from the sheath to the core and from the core to the sheath, and cause it to spread widely into the extrapolar regions.

Relation of Polarization to Excitation and Conduction.—Pflüger says that the beginning of our knowledge of electrotonus starts with the observation of Ritter ("Beiträge zur nähern Kentniss des Galvanismus," etc., Jena, 1802) that the irritability of a nerve is altered by the flow of a current, and differently for ascending and descending currents. The fact that the flow of an electric current through a nerve may lead to the development of electrotonus was first observed by DuBois-Reymond ("Untersuch. ü. thierische Electricität," Bd. ii., Abth. 1, S. 289, 1849). He considered excitation to be closely related to the electrotonic changes which he observed, and these to be associated with the electrolysis produced by the current. Although he recognized electrotonus and excitation to be intimately related, he did not regard the electrotonic state to be identical with the process of excitation as manifested by sensation and movement. His statement, "Galvanic excitation is only the first stage in the electrolysis of a nerve," has received support from many of the latest observations.

Pflüger recognized that there is a very close relation between the polar changes of irritability and conductivity which he observed and the polar electrical phenomena of electrotonus, but regarded them as the different symptoms of the internal molecular changes produced by the battery current in the nerve. DuBois-Reymond ("Untersuch.," Bd. i., S. 258) had formulated a general law for excitation, viz.: excitation is caused not by the continuous flow of a current, but by changes of intensity within short intervals of time, and Pflüger ("Untersuch. ü. d. Physiol. d. Electrotonus," S. 445, Berlin, 1859) interpreted this law to mean that excitation depends upon the rate at which the inner molecular constitution of the nerve is altered by the application of some external force, and found this law to be in harmony with his law of "polar excitation of nerve,"—"a given stretch of nerve is excited by the development of catelectrotonus and the disappearance of anelectrotonus, not, however, by the disappearance of catelectrotonus and the development of anelectrotonus" ("Untersuch.," S. 546). He associated excitation with the sudden rise of irritability which occurs at the cathode on the closing, and at the anode upon the opening of the current.

Hermann followed up the observations which Matteucci had made in 1863 on core-conductor models, and concluded that electrotonic currents and the electrical phenomena to be observed on nerves when they are excited, can be explained by the chemico-physical effects of the current; and further, that the explanation of the "law of polar excitation" developed by Pflüger is to be sought in the electrolytic changes which the current produces at the two poles. Hermann (Hermann u. Weiss, Pflüger's *Archiv*, lxxi., S. 279, 1898) states that as early as 1867 ("Untersuch. ü. Muskeln u. Nerven," Heft 2, S. 41–42, Berlin, 1867) he developed a theory that under the influence of the cathode the splitting up of chemical compounds in the tissue is hastened (dissimilation occurs), and so negativity is produced in the neighborhood of the cathode, and under the influence of the anode decomposition is delayed and perhaps synthetic changes produced, whence a condition of positivity is developed near the anode. He says that later he gave this theory up for a better one, but it has been accepted by many and was brought forward again by Hering and Biedermann ("Ber. d. Oesterr. Akad. Math. Naturwiss. Cl.," Abthl. 3, Bd. 997, S. 145, 1888; Biedermann, "Electrophysiologie," S. 706, Jena, 1895), who described electrotonus of the nerve as a physiological phenomenon and different from the physical change to be observed on core-conductor models. Through this some confusion in terminology arose. Bernstein classes under physiological electrotonus the changes in irritability, and under physical the galvanic phenomena produced by the current. Hermann is not satisfied that such a division is admissible, nor is it now generally accepted. Hermann (*loc. cit.*, S. 280) says: "For me all physiological phenomena of electrotonus are only effects of polarization of the nerve core, these being at once the result of the action of the current and the cause of its spread into the extrapolar regions." The assumed assimilation and dissimilation effects find place under the physiological action of positive and negative polarization. Boruttau (Pflüger's *Archiv*, lviii., S. 51, 1894; lix., S. 47, 1895; lxiii., S. 154, 1896; lxvi., 1897; lxviii., 1897; lxxxi., S. 360, 1901), in his many papers on this subject, favors the view that excitation always goes hand-in-hand with a catelectrotonic condition and that the current of action can be identified with "a wave-like spread of catelectrotonus." He arrived at the view through his experiments on core-conductor models, on which he claims that all the electrical phenomena to be observed on nerves can be reproduced. His experiments have shown an astonishing similarity beween the way in which electrical waves traverse these models and the way that the waves which accompany the nerve impulse pass along the nerve. Even very brief currents, such as induction currents, can cause catelectrotonus; and he finds that if a series of equal induction currents of alternating direction are passed through a portion of a core-conductor model, the opposite equal polarization effects cause a condition of negativity, of catelectrotonus, to develop near the electrodes on each side of the polarized region. Hoorweg (Pflüger's *Archiv*, lxxi., S. 128, 1898) as the result of his experiments comes to much the same conclusion as Boruttau, but Hermann (Pflüger's *Archiv*, lxxi., S. 294, 1898) states that he is not prepared to go as far as Boruttau, and does not consider that core-conductor models can be looked upon as nerve models in respect to irritability; they are, for him, models of electrotonic effects of the current. He considers that polarization, and the excitation associated with its development and disappearance, are to be held as distinctly separate phenomena. This year he writes (Pflüger's *Archiv*, lxxxiii., S. 360, 1901) with reference to the current of action and excitation: "One need not consider these as separate properties; on the contrary, for me excitation is nothing more than that change in the core which causes the potential of the current of action."

Pflüger found that the sudden cessation of anelectrotonus as well as the establishment of catelectrotonus is associated with a sudden rise of irritability and excitation. This is difficult to explain on the theory that excitation only occurs on the establishment of catelectrotonus. Gruetzner (*Breslauer aerztl. Zeitschr.*, No. 233, 1882) and Tigerstedt ("Mitthl. a. d. physiol. lab. d. Carolin. Instit. in Stockholm," Hft. 2, Abthl. 2, 1882) have tried to meet the difficulty by attracting attention to the fact that on the opening of the polarizing circuit a catelectrotonic condition is developed at the former anode, through the establishment of the polarization after-current of opposite direction. This explanation is not altogether satisfactory to Gotch (Schaefer's "Textbook of Physiology," ii., p. 499, 509, 1900) who points out a number of difficulties, and decides that something more than the effect of the after-polarization current must be at work in the production of the opening excitation; it appears to have been accepted by Hermann, Boruttau, and others who associate excitation with the catelectrotonic state.

The prolonged, more or less continuous excitatory condition seen to follow the opening of a strong current that has flowed through a nerve for a considerable time, and which is known as "Ritter's opening tetanus," like the continuous contraction which may develop during the flow of a strong current, is generally attributed to an irritation caused by the ions liberated at the two poles during the flow of the current.

Relation of Polarization to Conduction.—The excitation process is transmitted in nerves in the form of a wave, at a definite rate, without loss of energy; electrotonus is developed instantaneously, is a stationary condition, and lessens in intensity with increasing distance. As Waller ("Lectures on Animal Electricity," p. 114, London, 1897) states, both electrotonic currents and currents of action are expressions of polarization, but the former is a stable, the latter a fleeting change, propagated as a wave along the compound electrolyte. If this be true, how can the excitation associated with the development of catelectrotonus result in conduction? Hermann (Pflüger's *Archiv*, lxxv., S. 574, 1899) recalls that as early as 1872 he expressed the view that the polarization which occurs at the bounding surfaces of the axis cylinder and the sheath of the nerve might play a part in the conduction process. He says there are two laws of the utmost importance in this connection, that of Pflüger, that a part of a nerve is irritated when catelectrotonus increases and when anelectrotonus diminishes, and his own law of the current of action, that every cross section of a fibre is negative in respect to one less irritated or not irritated. Since an irritated part of a core is negative with reference to neighboring parts which are at rest, currents would be set up which would flow from the core through the sheath and back to the core. These currents would act catelectrotonically to excite the neighboring inactive parts, and anelectrotonically to inhibit the part which had been irritated. On this basis, as the wave of excitation passes, each point becomes first catelectrotonic and then anelectrotonic. The idea that an anelectrotonic condition immediately follows a catelectrotonic explains for Hermann why it is that not all the available energy-producing substance made irritable by the condition of catelectrotonus is used up by a single excitation. Werigo (Pflüger's *Archiv*, lxxxiv., S. 618, 1901) thinks that it is unnecessary that anelectrotonus should thus follow catelectrotonus, because, if currents are of short duration, the rapid rise of excitability at the cathode is always followed by an immediate fall of excitability. Hermann (Pflüger's *Archiv*, lxxiv., S. 582, 1899), at the close of a paper in which he attempts to give a mathematical expression to his theory of nerve excitation, writes, "The irritation works on the current formation just like self-induction," but he says that we cannot assume self-induction for protoplasm.

Hermann's theory of the conduction process requires excitability in the conducting part, and the claim has been made by a number of investigators (Gruenhagen, Efron, Gad and Sawyer, Goldscheider, Piotrowsky) that they have observed conductivity in parts of a nerve which had lost their excitability, through the application of cold or some narcotizing drug. The excitation wave is evidently closely associated with a wave of electrical negativity, but the question arises, Are these to be regarded as inseparable in the case of nerves? The current of action can be demonstrated on a core-conductor model where there can be no question of excitation; and, as Hermann observes, a platinum wire is not a model of an irritable nerve, but only one to illustrate its electrical properties. Gotch and Burch (*Journ. of Physiol.*, xxiv., p. 144) found in experiments in which two rapidly following excitations were given to a nerve, different parts of which were at different temperatures, that excitation can pass along a stretch of nerve without a current of action developing. Herzen (*Centralbl. f. Physiol.*, xiii., S. 455; *Revue Scientifique*, January 13th, 1900) found that a nerve poisoned with chloral, and presumably not irritable (since no muscular contractions resulted from excitation), was still able to conduct and give a negative variation. Radzikowski ("Ins. Solway, Travaux de lab.," iii., fasc. 1, p. 1, 1899) found currents of action in nerves which were apparently not functioning, since they did not excite the muscles. According to him, the current of action is simply a chemico-physical change resulting from the core-conductor structure, and not essentially connected with function. These results are by no means generally accepted. Thus Wedensky (Pflüger's *Archiv*, lxxxii., S. 124, 1900) considers that excitability and conductivity are inseparably connected, and Boruttau (Pflüger's *Archiv*, lxxxi., S. 360, 1900; lxxxiv., S. 325, 1901), after reviewing the work that has been done by others on this subject and describing a large number of experiments of his own, concludes with a reiteration of the view, already frequently expressed by him, that the appearance of currents of action without true functional activity of the nerve or the reverse never occurs.

There can be no doubt that electrolysis and the consequent polarization phenomena can exist independently of excitation, for they are to be observed on core conductor models in which there is no question of excitation in the physiological sense. All the electrical phenomena to be detected on nerves can be reproduced on core-conductor models, and, therefore, we are justified in assuming that in the nerve as in the model they may be chemico-physical processes. This conclusion does not prevent us from considering the electrical phenomena detected in nerves as physiological processes, for they are to be found in nerves only so long as the chemical and anatomical structure peculiar to living protoplasm is maintained, and are modified by any influence which alters the functional activity of the tissue. Probably strengths of current capable of producing excitation will always produce, if suitably applied, polarization, but it by no means is sure that polarization effects may not occur independently of excitation.

Although we cannot say that polarization and excitation are identical, it is evident that they are very closely related and can be considered as two different symptoms of the same chemico-physical changes of the living protoplasm. The closeness of the relation is made evident by the fact that they are influenced in the same way by so many different conditions. Both excitation effects and polarization are most marked in medullated nerves; both require the integrity of the nerve fibre, and both are altered in a similar manner by most of the influences which affect the activity of nerve protoplasm; both are increased when the length of nerve subjected to the current is increased; both are increased by an increase in the intensity and duration of the current; currents of very short duration, such as induction currents, can produce polarization as well as excitation; finally, the more rapidly polarization develops the greater the excitation.

Warren P. Lombard.

ELEMI.—Of the several resins which at one time or another have been sold under this name, that in use at present is the one known as Manilla elemi, and comes from the Philippines.

Elemi exudes from incisions in the bark of one or more species of *Canarium* (fam. *Burseraceæ*). *C. commune* L., of India, yields one variety, but it is apparently not that now in use, which comes chiefly from the island of Luzon.

Elemi is a soft, translucent, grayish-white or yellowish substance, of pleasant aromatic odor, and rather terebinthinous taste. It comes in large cakes or masses, often very much contaminated with dirt, chips, and leaves. The British official description is as follows: "When fresh, soft, granular, resinous, and colorless, but by keeping it becomes harder, and of a pale yellow tint. Odor, strong and fragrant, somewhat resembling fennel and lemon. Moistened with rectified spirit, it breaks up into small particles, which, when examined by the microscope, are seen partly to consist of acicular crystals."

Composition.—According to Flückiger it contains ten per cent. of *essential oil*, which may be separated upon fractional distillation into six portions, all of the turpentine series, $C_{10}H_{16}$, or C_5H_8. The remaining resin is a complex mixture, from which several crystalline, resinous substances—*amyrin*, *bryoidin*, *breidin*, etc.—and amorphous resins have been separated. *Elemic acid* is finally another ingredient.

Action and Use.—Elemi is a local stimulant, like turpentine and resin, and is put to the same uses. Its only employment here, and that quite rarely, is as an ingredient of plasters and ointments. *Unguentum Elemi* was made of elemi one part and simple ointment four parts.

W. P. Bolles.

ELEPHANTIASIS.—(Synonym: Elephantiasis Arabum; Barbadoes leg; Morbus herculeus; Spargosis of the Egyptians; Pachydermia; Sarcoma mucosum; Tropical big leg; Bucnemia tropica; Hypersarcosis; Phlegmasia malabarica; Mal de Cayenne.)

Definition.—A non-contagious endemic or sporadic disease, characterized by a chronic hyperplasia of the true skin and subcutaneous tissues; usually limited to an exclusive locality, and preceded by a local disturbance of the circulation, especially in the lymphatic vessels; and terminating in swelling, œdema, induration, progressive hypertrophy, more or less pigmentation, the development of fissures, and the growth of the papillæ.

Owing to its great antiquity and the prominence awarded it by the earliest medical authorities, elephantiasis must be regarded as a disease of phenomenal interest. Its name would seem to imply that it originated in Arabia; indeed, according to the most ancient history of medicine, it first prevailed in that country and was of common occurrence. Formerly the term was practically unlimited in its application and failed to express with even approximate accuracy the various forms and phases of the disease. It apparently embraced all the morbid conditions of the human body which involved the enlargement of a specified part, and pointed particularly to the condition described as lepra græcorum. Truly, this was a most unfortunate name, as it was many times applied to lesions of a totally different pathological character. Happily, however, the employment of this generic term for diverse morbid processes has finally been discountenanced, being at present confined to a single disease.

While elephantiasis is a typical pandemic disorder, characterized by wide differences, it is either endemic or sporadic in its distribution, differing symptomatically as to its exciting causes, but with like results in all cases.

The endemic form is essentially a disease of the tropical and subtropical regions, appearing most frequently in Africa, India, the Indian Archipelago, the West Indies and South America. The sporadic form occurs all over the world; the endemic type is rarely encountered beyond the 35th degree of North and South latitudes. In Travencore it is very common, affecting about five per cent. of the entire population, while in some of the South Pacific Islands nearly one-half of all the inhabitants are its victims.

In the United States the disease is comparatively rare, being more prevalent in our territorial possessions and in the South than in the North, where, indeed, it does not seem to spring from the same cause. The pathological process is so different in the two groups of the disease, as to etiology, symptomatology, and course, that there seem to be two distinct types of the disease, covering a multitude of hypertrophic conditions, such as result from congenital elephantiasis, telangiectodes and lymphangiectodes, or acquired obstruction of the lymphatic system, and including cases of chronic phlegmasia dolens and hypertrophy originating in chronic eczema and varicose veins.

The endemic form declares itself somewhat suddenly, and is accompanied by pain and inflammation of the parts affected, more or less well-marked febrile symptoms, and the so-called elephantoid fever which is usually characterized by a prodromic stage, generally following over-exertion or injury, chills, high fever, and gastric disturbances.

The inflammation is of an erysipelatous character, and chooses the lymphatics and blood-vessels as its points of attack. Often the lymph glands of the groin and armpit become swollen and extremely sensitive. A lymphatic streak of a rose color is frequently seen to traverse the skin which, when palpated, seems to present a line of knots; the region involved becoming reddened, hot, painful, œdematous, and swollen.

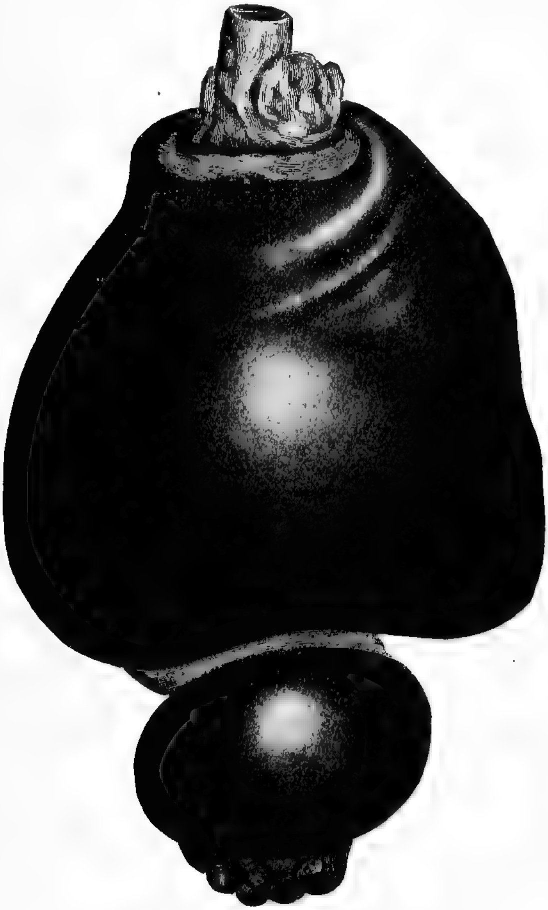

FIG. 1856.—Elephantiasis Tropica of Leg. (Crocker.)

In a few days the constitutional symptoms subside, and so also, as a rule, does the swelling; a slight thickening, however, may remain. The further course of the disease is marked by repeated attacks, at irregular intervals, of lymphangitis and lymphatic œdema. These may be repeated once or twice in a single month, or may be delayed for a whole year. As a rule, the oftener the attacks occur the less intense is the general reaction; while, on the other hand, there occurs, each time, additional hypertrophy of the region affected. Finally the affected part becomes permanently enlarged, hard to the touch, and dark in color, with folds beneath which dirt and offensive discharges collect; hence the comparison, if the disease affects the lower extremity, to the elephant's leg. In the interval between any two attacks, if protracted, the swelling somewhat recedes, but afterward it increases again. As a consequence of the recurrent inflammation, enormous and persistent hypertrophies result. Sometimes there are slight tension and firmness of the affected parts, but at other times they show a discoloration consisting of various shades of red. After a few attacks, a fold of skin, when pinched, reveals an appreciable thickening. Repeated attacks result in still further thickening of the skin and subcutaneous connective tissue, the skin becoming harder, firmer, non-resistant, and more tensely fastened to the substratum. In extreme cases, the deep fascia, the sheaths of the blood-vessels, and the periosteum are involved. The condition is furthermore favored by the stasis of the lymph in the channels and obstructed glands, resulting in a dilatation of the lymphatic trunks, which become indurated, tough, and stringy. Ultimately, they and the surrounding connective tissues become fused together into a uniform, hard mass.

The changes which take place upon the exterior of the integument, after the lapse of a year or more, are manifold. At first the skin is usually dry, shiny, smooth, and tense; a little later it becomes discolored and is found to be rough, tawny, ichthyotic, and pigmented. The natural folds and furrows are greatly exaggerated, and often present irregular fissures especially pronounced at the bases of the folds, under which the epidermis is apt to become macerated and decomposed, as a result of which there is an offensive discharge. The papillary layer is frequently modified in that it may be uniformly thickened like the whole skin, or this may occur only at certain points, forming the verrucous projections often encountered about the arch of the foot or between the folds of the integument. While the structural change of the papillary layer is not always the same, it may be said that thickening of the epidermis is generally associated with hypertrophic papillæ.

This disease is calculated to give more or less annoyance to the patient, not alone because the parts are cumbersome, but for the reason that great deformities of the toes may result from atrophy and dislocations. The nails, too, may contribute to the characteristic discomfort by undergoing some kind of degeneration. Occa-

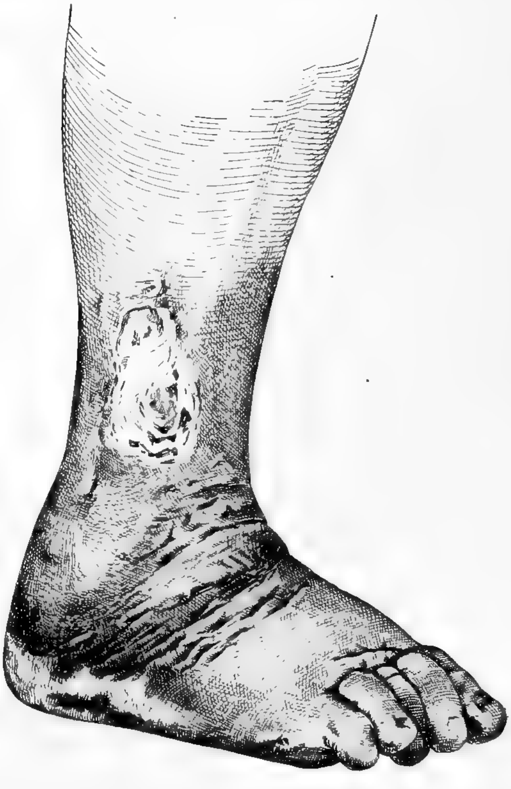

FIG. 1857.—Elephantiasis of the Leg Resulting from Varicose Ulcer. (Chatelain.)

sionally even the bones show a change. Osteophytes may arise, particularly near the insertion of a muscle or sinew, or at the borders of the epiphyses, and eventually the bone undergoes necrosis and ulceration. In addition to interference caused by the deformity, the function of the limb becomes greatly impaired from the hypertrophy of the structures of the soft parts and from atrophy of the bones and muscles. The resulting inconvenience is considerable, especially when the disease affects the lower portion of the leg. Other local discomforts may arise. Thus, for example, eczema is sometimes set up, at other times varicose ulcers are formed, and, in rare cases, rupture of the lymphatics ensues. All these are no doubt secondary consequences of the disease, but they greatly aggravate the suffering of the patient. Again, severe and continuous pain, usually of a neuralgic character, may accompany the disease. Occasionally elephantiasis may be associated with complications; these are found to be most numerous in the endemic variety. They consist, as a rule, of suppuration of the inguinal glands, and of cellulitis with subsequent abscess formations.

The sporadic form, like the endemic, very often declares itself in recurring attacks of lymphangitis, but differs from it in these particulars: the constitutional symptoms are not usually as severe, and the enlargement is more equally distributed about the limb and not so often associated with the section below the knee. Cases resulting wholly—or nearly so—from chronic irritation, without any acute inflammatory signs, would seem almost to constitute an entirely different class. However, these two types—the endemic and the sporadic—are so similar clinically that they must be considered as one. It is not difficult to see that repeated inflammations have greatly interfered with the venous and lymphatic circulation; the limb has therefore been chronically congested, and a superabundance of lymph has been constantly present in the subcutaneous cellular spaces. This condition finally becomes more pronounced and results in the hypertrophy and induration so characteristic of elephantiasis. In rare cases the acute and chronic inflammation, which may be regarded as the cause of the disease, are wanting.

The particular portion of the body most frequently attacked is the leg, yet the hypertrophy frequently appears elsewhere, as, for example, in the scrotum, penis, labia, hand, arm, face, and ears. Apart from the extremities it may be stated that it is most often met with in the scrotum, which has been known to attain a weight of more than one hundred pounds, and actually to reach the ground. When the male genitals become the seat of the difficulty, we have symptoms and complications peculiar to these parts. The symptoms referred to, in addition to the constitutional ones and the recurring attacks of lymphangitis, are both systemic and local. For, besides the usual chills and fever, we often encounter nausea and vomiting, associated with severe pains in the groin, radiating from the spermatic cord, with subsequent swelling of the locality. The attack may be acute, in consequence of the disturbance in the circulation, this being especially true when the inguinal glands are greatly inflamed and swollen, and when there is a chronic inflammatory affection of the penis and scrotum. Strictures, urinary fistulæ, and incontinence of urine are frequently the source of the disease. The cutaneous covering of the scrotum and penis soon loses its sensitiveness and becomes indurated, rough, and rugose. The prepuce is lengthened and thickened and the skin gradually becomes hypertrophied. When the scrotum is involved, the raphé and the natural folds and furrows are greatly exaggerated; beneath these, dirt and dribbling urine from a retracted penis collect, and give rise to the formation of excoriations, fissures, and ulcerations, accompanied by offensive discharges. We also find hernia and hydrocele frequently associated, as complications, with elephantiasis of the scrotum.

Lymph scrotum is a peculiar form of the disease known as nevoid elephantiasis; this is frequently associated with hæmaturia, chyluria, and a varicose condition of the lymphatics of the scrotum, apparently due to the presence of the Filaria sanguinis hominis. It is characterized by the presence of enlarged vessels arranged in lines or groups, which vary in diameter from a pinhead to a bean, and which, being opened, exude a pinkish, milky fluid which readily coagulates. In its incipiency it is attended with chills, fever, and erysipelatous inflammations; the inguinal glands on one or both sides are swollen; and, sometimes, there is inflammation of the testicles.

Elephantiasis of the female genitals, in the temperate zone, is more frequently met with than its congener in man, but in the tropical and sub-tropical climates these organs are less often assailed. The parts generally affected are the vulva, the labia majora, less often the labia minora, and rarely the clitoris. The sporadic variety is remarkable in that it is comparatively mild and seldom presents the intense features found in the endemic type. In this variety the development of the disease may be slow and painless, or very rapid. It is usually characterized by symptoms which indicate that it is the result of some irritation, as onanism, or of some local affection, as syphilitic inflammation, which, in addition to the irritation, obstructs the circulation of the lymphatics. Benign tumors which appear early in childhood, or congenital malformations may serve to explain the subsequent hypertrophy.

The entire vulva is not always involved, but usually the labia majora become affected. Should the lesser labia fail to escape the influence of the disease, they will often become the seat of a spherical or pear-shaped tumor, for the most part small, although sometimes attaining considerable size. The skin restricted to this region may become either smooth and somewhat tense and firm, or wrinkled and covered with dilated sebaceous glands with gaping orifices; or it may show warty growths arising from the enlarged papillæ. In the latter case the entire surface of the vulva, as far as to the anus, may be covered with these warty growths. The surface, owing to the presence of distinct and hypertrophic papillæ, reveals numerous rifts and fissures. The development of the disease in these parts is generally quite slow, a number of years being necessary to produce tumors as large as a hen's egg, but at times the pathological change occurs more rapidly, and then the masses may attain enormous dimensions. Even when these growths are small, the patient often suffers from rhagades, fissures, and ulcerations, which, if not actually painful in themselves, are always troublesome by reason of the irritation caused by the acid excretions. The mucous membranes of the urethra and vagina also, under these conditions, often throw out a discharge which is of an irritating character.

While the various localities mentioned may be susceptible to elephantiasis, it would nevertheless appear that only the lower extremities and the genital organs, owing to the frequency with which they are attacked and the extent of the hypertrophy, deserve here to be considered. The portions of the body most usually attacked are the leg and the scrotum; all other sites are so rarely implicated that a detailed description thereof seems unnecessary, the characteristic symptoms having already been sufficiently indicated in discussing the preceding forms.

Elephantiasis of the face and head usually presents a lobulated appearance without well-defined borders. It generally results from frequent attacks of erysipelas, or it follows a chronic eczema, or, finally, it may be due to traumatism. The entire face may be affected, or only a single section, as the forehead, ears, lips, and nose. Elephantiasis of the mammæ occurs only in women and never before puberty. It generally manifests itself during pregnancy or lactation and is almost invariably of the endemic type. In the tropics the female breast has been known to develop into a colossal tumor, large enough to extend down to the patient's knees, and at the same time the effected skin has shown a marked tendency to ulcerate.

Finally, elephantiasis is sometimes congenital. This form resembles the sporadic or the endemic variety in its anatomical characteristics, but differs from them not only in origin but in general symptoms. Instances of congenital lymphangiectatic macroglossia and macrocheiria are occasionally met with. Cases of circumscribed lymphangiectasis of the skin are also sometimes encountered, and from their resemblance to tumors they are classified as lymphangiomata. Well-defined elephantiasis due to congenital causes is not frequent in temperate climates.

Typical instances of the malady in tropical countries have been made the subject of interesting monographs by Moncorvo, of Rio de Janeiro, in which he graphically depicts the facial and manual deformities. He discovered the presence of streptococci in the blood and he believes that they were the exciting cause. They found their way into the maternal circulation, as he believes, through the placenta, from a previous injury to the abdomen. Some authorities attribute the development of this peculiar disease to the filaria or its embryos, others regard it as the result of hereditary syphilis.

In a sporadic case which was reported by Dr. Ernest Wende, and which developed in intra-uterine life, it was found, upon microscopical examination, that the connective tissue of the skin was greatly thickened, especially in the papillary layer; the sweat glands were distorted; the muscles had undergone fatty degeneration; the walls of the blood-vessels were thickened and some of them were obstructed. Similar changes were met with in the lymphatics. The lymph spaces were enlarged and dilated. Round-cell infiltration was present. No filariæ or embryos were found. It was concluded that the etiology of this disease is not subject to a single law, as now held by some authorities, but is due to several distinct causes. Fig. 1859, copied from a photograph, shows the gross manifestations of the disease in this particular case.

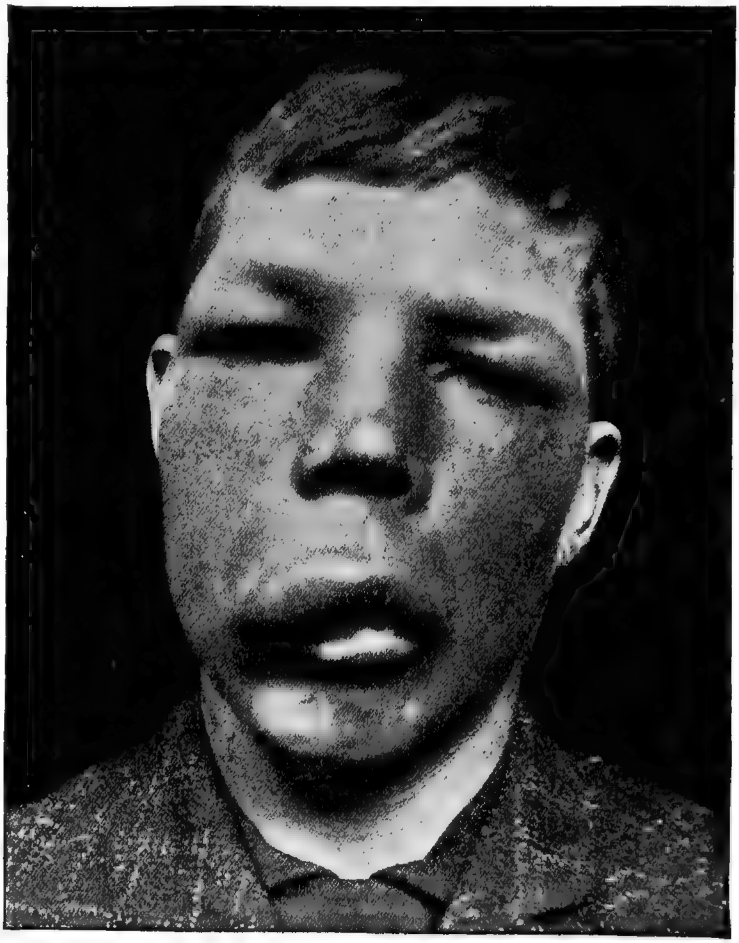

FIG. 1858.—Elephantiasis of the Upper Lip and Portions of the Face. (Hyde and Montgomery.)

ETIOLOGY.—This affection occurs at all ages, but is especially found in connection with adult life. It attacks both sexes, but the male sex in the ratio of four to one, a fact undoubtedly due to greater liability to exposure. It is developed in all countries and climates, but is more commonly found in the island and coast territory of tropical and subtropical regions. In the endemic form, it most frequently occurs among the natives. Sir Joseph Fayrer states that in India, if the disease occurs among Europeans, it is always among those who possess an admixture of native blood. On the other hand, Manson says that racial peculiarities do not play a vital part in the problem, but that the Europeans, owing to their education and habits, are less exposed and therefore less liable to contract the disease.

Many observers emphasize the possibility that heredity is either the direct cause of the endemic variety of the disease, or that it creates a predisposition to it and enters into the problem as a factor. In support of this theory, it has been observed that the disease has existed in the same family for several generations. It should be borne in mind, however, that the individual members of such families are usually exposed to the same general influences of climate, habits, and mode of living. Moisture, damp and swampy regions, and unhygienic surroundings in general may have a bearing upon the etiological relations of the disease, inasmuch as such conditions are allied to the habitat of the mosquito; this especially applies to the poorer classes. While the disease is often found in mountain districts, rapid changes of temperature and exposure to the sun or damp are more frequent causes.

The question whether elephantiasis is not a specific disease depending upon a specific cause—for instance, a true parasite—has been freely discussed by Carter, Lewis, and Bancroft, and especially by Manson. In the endemic variety such a connection has been established, and it appears that its existence is associated with the Filaria sanguinis hominis, known to exist in malarial districts, and which readily finds a habitat in the blood-vessels and lymphatics. There is a strong probability, according to Manson, that the disease owes its origin to a certain species of mosquito. Quite recently, Dr. Low and Capt. James, while working with mosquitoes, claimed to have discovered that these belong to the genus anopheles as well as the genus culex, and that the former more frequently acts as an intermediary host.

In considering the etiology of the sporadic variety, we are able to gain a clearer comprehension of the disease, one which includes all the pathological factors producing lymphangitis and all kinds of atypical forms of inflammation, especially erysipelas. The question arises whether these repeated attacks of inflammation constitute a true erysipelas, or a lymphatic process peculiar to elephantiasis alone. The consensus of opinion is that the streptococcus discovered in several cases corresponds to a specific cause different from that which produces genuine erysipelas. However, a true erysipelatous condition may precede elephantiasis, if the local conditions are favorable, as is often the case when ulcers, fissures, or lymph fistulæ are present. It is difficult to ascertain the cause of the many cases of elephantiasis that occur sporadically in our climate, for the affection is apparently occasioned by various factors, favoring the theory of a recurrent inflammation and obstructions of a lymphatic œdematous character. For instance, when the disease begins in the lower extremity, any local process or factor calculated to impede the venous circulation—as by compression from scars, or by means of a thrombus resulting from a phlebitis, or even by means of a frost-bite—may possibly give rise to the difficulty. In fact, it may be caused by any decided inflammation of the soft parts. To the last-named category chronic eczema, syphilis, lupus, ulcers, and fistulæ especially belong.

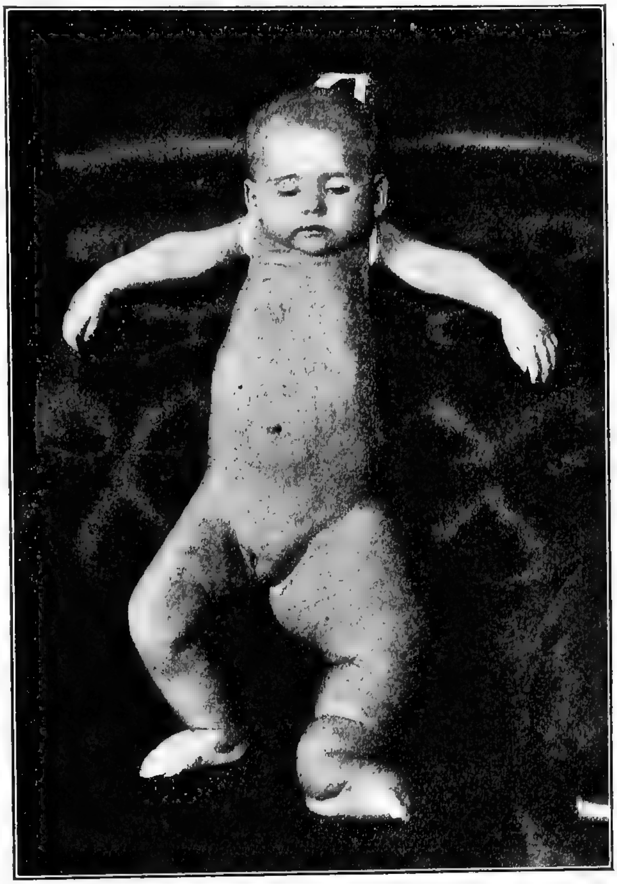

FIG. 1859.—Congenital Elephantiasis. (Dr. Ernest Wende.)

PATHOLOGY.—The pathology of this malady is peculiar in that, irrespective of the specific causes,—of which there are a number,—the resulting changes are invariably the same.

The peculiar characteristics are a cell proliferation and hypertrophy which involve in a varying degree all the structures of the affected parts. Implication of the fibrous tissue constitutes, perhaps, the most prominent feature of the disease and produces the bulk of the mass, the process involving the true skin, blood-vessels, lymphatics, and the structures of the nervous and muscular systems. The various layers of the skin become so matted by reason of the enormous increase in the fascicles of the fibrous tissue that they can hardly be distinguished. The corium is greatly thickened and indurated, and in certain localities the process is so marked as to produce verrucous elevations. The sebaceous and sweat glands, as well as the hair follicles, are at first usually unchanged, but subsequently are widely separated or, in consequence of hypertrophic pressure, become atrophied and scarcely perceptible, often plugged and their walls thickened. The fasciæ and intermuscular septa are greatly augmented, and present evidence of fatty degeneration. Upon section, the parts show the hypertrophic tissue to be fibrous, lustreless, sclerotic, and homogeneous, and a lymph-like fluid exudes. In certain cases dilated lymph pockets appear, from which lymph or chyle escapes, supposed to result from the obstruction of one or more large lymph trunks.

Tropical elephantiasis is now known to be caused by the partial or complete obstruction of some lymphatic vessel or gland by the filaria or its embryos, these having been discovered in the peripheral lymph vessels, in many cases involving the scrotum and lower extremities. The question of its being a parasitic disease, particularly in that form which is found in hot countries, has been fully discussed by Wucherer, Lewis, and especially by Manson. The filaria has been found in those suffering from other diseases, both in man and in some of the lower animals, but without causing any apparent inconvenience. It exists in some cases without reaction and without any evidence of elephantiasis. In view of these facts, therefore, the evidence that the filaria is in itself the exciting cause of the disease is not complete. All we can say is that it represents one of the many causes which may develop the disease in hot countries when other etiological factors are present.

The adult male and female filariæ that gain entrance to the lymphatic vessels, thus causing a stasis of the lymphatic fluid of which elephantiasis is the consequence, measure, respectively, the male 83 mm. in length by 0.407 mm. in thickness, the female 155 mm. in length by 0.715 mm. in thickness, while their embryo measures 14 mm. by 0.038 mm. In appearance the parasite is long, smooth, round, and opaline. According to the opinion of Manson, the parent worm occupies some portion of the lymph channel, at which place its ova are discharged, to wander through the lymph glands and general circulation. These embryos have a diameter scarcely larger than that of a lymph corpuscle. Manson states that they are abstracted from the blood by the mosquito, and by it introduced into the water stream, which ultimately affects man through contamination. Filaria embryos disappear periodically from the blood and reappear in the same individual, this phenomenon depending on the habits of the host. It has been ascertained that during the day the filariæ are absolutely wanting in the blood, while in the evening and at midnight they are largely in evidence. The presence of filariæ may also depend upon the nocturnal habits of the mosquito. It has not been shown with absolute certainty whether the filariæ which appear during the night come in freshly from the lymph vessels and then die, or whether they assert themselves alternately in the blood and lymph. The discovery of filariæ in the blood depends very much upon the precise time of examination, which often proves to be negative. So long as the patient is active, no specimens of the parasite are likely to be discovered; but usually a moderate number of embryos can be found after the patient has been in bed for a short time.

TREATMENT.—In the endemic type, in order to secure immunity from filarial complications, prophylaxis is important. The drinking-water, unless collected in cisterns that are protected from mosquitoes, should be filtered or boiled. In sections favorable to the disease, the individual should always sleep under netting. In suspicious cases, remedial measures should be promptly applied to all injuries received. All cases may be greatly benefited by a change to a country that is free from malarial and miasmatic influences; for it has been observed that even if the disease is far advanced the severity of the paroxysmal attacks will be lessened by the removal to a different country.

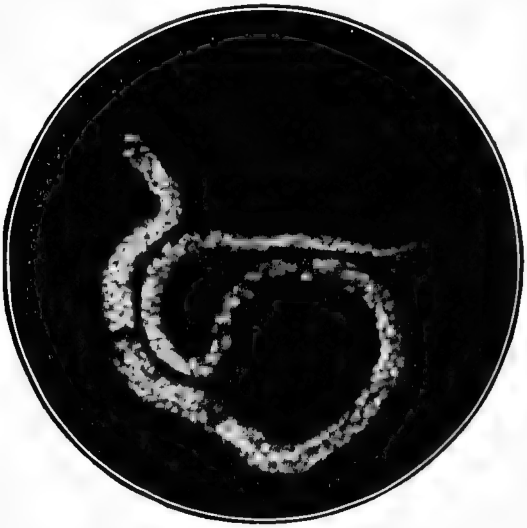

FIG. 1860.—Filaria Sanguinis. (Photomicrograph by Dr. Harvey R. Gaylord.)

Surgical interference of one kind or another has never accomplished any definite result in these cases. That the embryos which are usually lodged in the glandular structure, after being hatched, enter the general circulation of other portions of the body, is capable of demonstration.

The measures commonly adopted in connection with this condition, especially when preceded by chills and fever, are such as will most successfully combat inflammatory processes. The effect of such remedies will be to counteract the fever, lessen exudation, and diminish stasis. The medicines generally employed for this purpose are quinine, salines, phenacetine, or any other suitable antipyretic, while soothing and astringent lotions, like lead-water and opium, zinc oxide, and boric acid may be applied locally until the inflammatory action has subsided. After the intercurrent attacks, tonics, such as iron, cod-liver oil, strychnine, and mineral acids, may secure beneficial results.

The sporadic cases which are met with in our country are best treated by counteracting the cause. If the disease is the result of an ulcer on the leg, this should be promptly healed, its excrescences removed, and the limb maintained in an elevated and horizontal position. Afterward it should be methodically compressed with a rubber bandage. The toes should be separately enveloped, then the foot and ankle, and lastly the leg, so as to diminish the œdema. When elephantiasis of the leg has reached such proportions that bandages no longer serve, ligation of the arteria femoralis and of the iliaca externa must be resorted to. In certain instances these measures have proved effective and they should be tried in extreme cases. In acute attacks the parts may be punctured—in order to lessen the effusion by providing an escape for the fluid—and antiseptically dressed with an astringent lotion or ointment.

In a few instances nerve-stretching and partial excision of the sciatic nerve have been followed by beneficial results. In elephantiasis of the scrotum the removal of the offending mass by the knife sometimes becomes indispensable. The mortality resulting from heroic treatment is comparatively small. Before operating, Fayrer recommends drawing off the blood by placing the patient on his back, elevating the tumor and compressing it with an elastic bandage. The incision is to be made alongside of the cord and at the root of the penis. The skin is reflected and the cord, testicles, and penis protected by turning them out; the mass is then quickly removed, only a few bold incisions being required.

The female genitals, almost without exception, demand surgical interference. For this purpose either the knife or the galvano-cautery may be employed. The latter method is simply and especially adapted to cases of hypertrophied labia. Amputation of the leg has also been resorted to, but the operation has not been characterized by the same success as has attended it in other regions affected by the disease.

PROGNOSIS.—The prognosis largely depends not only upon the particular form of the disease, but upon its complications. It is evident from what has been said that the disease is not necessarily fatal—even the endemic variety vastly improves under a change of climate. This is likewise true of sporadic cases. Both surgery and medicine have rendered even aggravated cases comparatively curable. The duration of life is not usually shortened by elephantiasis, since it exerts no detrimental influence upon the general constitution. Death rarely ensues from it except in those cases which involve suppuration or septic infection.

The necessary literature relating to this subject is to be found in the following books: A. von Winiwarter: "Chirurgischen Krankheiten der Haut"; Hyde and Montgomery: "Diseases of the Skin," "Twentieth Century Practice of Medicine," vol. iv.; "Albutt's System of Medicine," vol. ii.; "La Pratique Dermatologique," vol. ii.; and the London Lancet and British Medical Journal, 1880 and following years. *Grover W. Wende.*

ELGIN SPRINGS,—Addison County, Vermont.

POST-OFFICE.—Vergennes. Boarding-houses.

ACCESS.—Viâ Vermont Central Railroad to Vergennes, thence three miles south by stage. This resort is pleasantly located in the Champlain valley, surrounded by beautiful scenery and delightful drives. The summer temperature generally ranges from about 50° to 70° F., and the weather is usually clear and bracing. The following analysis of the springs was made in 1889 by Henry M. Sully, of Middlebury College:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Silica	1.19
Calcium	24.61
Magnesium	25.10
Sodium	11.30
Chlorine	.34
Sulphuric acid	87.65
Carbonic acid	1.08
Iron	Traces.
Total	151.27

Temperature when drawn, 45° F. The compounds formed by these acids and bases have not been designated by the chemist, but it can readily be seen that they would consist largely of sulphates with an admixture of carbonates and chlorides. The water contains a considerable proportion of sulphate of magnesium and some sulphate of sodium which gives it a cathartic effect. It resembles the waters of Seidlitz and Pullna in Bohemia and is valuable in chronic constipation and in blood disorders. The water is slightly opalescent when fresh, faintly alkaline to test paper, and odorless. It becomes perfectly clear after standing. *James K. Crook.*

ELM, SLIPPERY.—ULMUS, ELM BARK. "The dried inner bark of *Ulmus fulva* Mx. (fam. *Ulmaceæ*)" (U. S. P.). This is a smaller and less graceful tree than the common "American," or white elm, *U. Americana,* which it in general resembles. It is a moderate-sized tree, with a brown, rough bark, and soft, but tough, red wood. The leaves are larger and thicker than those of the common elm, and rough or pubescent beneath, and the fruit is twice as large. The expanding buds and smallest twigs are velvety. The inner bark of most elms, as well as of many other species in the order (nettles, hemp, etc.), is very pliable and tough; that of the present species is also very mucilaginous, and is valued on this account.

This is a common tree in the United States, especially in the central portions; but the demand for its bark has exterminated it from many regions, which suggests the question whether it could not be collected in such a way as not to destroy the tree, as is done with the barks of cinchonas in India.

The bark should be collected in the spring. It is "in flat pieces, varying in length and width, about one-eighth of an inch (3 mm.) thick, tough, pale, brownish-white, the inner surface finely ridged; fracture fibrous and mealy; the transverse section delicately checkered; odor slight, peculiar; taste mucilaginous, insipid." It contains no starch, a fact which affords an excellent means of detecting the numerous starchy adulterants of the ground bark.

Slippery elm bark is remarkable for the abundance of mucilage which it imparts to either cold or hot water, making a nearly transparent, thin, jelly-like, but not filterable solution. It is precipitated by neutral acetate of lead. The addition of strong alcohol to the concentrated mucilage abstracts a portion of its water without coagulating it.

The employment of slippery elm is said to have been learned from the aborigines. In medicine it is used as a pleasant demulcent, like other gums and mucilages; in sore throats, diarrhœas, dysentery, inflammation of the bladder, etc.; also as a poultice. It is a very mild agent, and has hardly any value, excepting that of an unirritating protection to the parts it reaches. The crude bark, chewed and swallowed in large quantity, has been the mechanical cause of serious consequences in one or two cases.

ADMINISTRATION.—The powdered bark, stirred into hot water, is sometimes used as a demulcent drink. It, of course, includes the woody dust, and is an unsightly mixture. The official mucilage (*Mucilago Ulmi*), made from the sliced bark and strained (six per cent.), is much better. Dose indefinite. The powder can be used for poultices. It is often mixed with flaxseed for this purpose.

ALLIED PLANTS.—Several other elm barks are mucilaginous, but none so much so as this. The European elm (*Ulmus campestris* L.) is official in several countries. It is slightly astringent. *W. P. Bolles.*

EL PASO DE ROBLES HOT AND COLD SULPHUR SPRINGS.

—San Luis Obispo County, California. Hotel and cottages.

These springs lie in the beautiful valley of the Salinas River, about 16 miles from the shores of the Pacific Ocean and 216 miles from San Francisco. They are reached by the Southern Pacific Railroad viâ Soledad. Access may also be had from San Luis Obispo by stage. The name of El Paso de Robles is derived from the Spanish, meaning "the pass of the oaks," from the fact that the main highway ran through this valley. For many miles this picturesque valley is covered with gigantic white oak, live oak, and cottonwood trees, and nestled in one of these cosy groves is Paso Robles Retreat. The once wild "pass in the oaks" is now transformed into a blooming resort, with cultivated grounds, and Paso Robles is a delightful little town of about a thousand inhabitants. When the Southern Pacific Railroad is completed the place will become of considerable commercial importance. Near the springs and overlooking the prosperous little town a commodious and elegant hotel is under construction. The building is of solid brick throughout. Some eighteen or twenty cottages are also found under the umbrageous oaks in different parts of the extensive grounds. On each side of the resort and valley the evergreen hills covered with forests of pine, oaks, manzanita groves, and sweet-scented shrubbery, form a pleasant contrast to Paso Robles proper. The climate is remarkably mild and delightful all the year round, and the atmosphere is pure, balmy, and invigorating. The waters of Paso Robles are sulphurous and alkaline and range in temperature from 59° to 122° F. They comprise the "Main Hot Sulphur" spring, the "Mud" or "Moor" spring, the "Soda," "Sand," "Cold," "White Sulphur," "Iron," and "Garden" springs. The great hot sulphureted spring is located about three hundred yards from the hotel in a southeasterly direction. Over it has been constructed one of the finest bathing establishments on the coast, consisting of sixty individual bath-tubs, and a large vat, fifteen by thirty feet, for a swimming or plunge bath. The flow of this spring is about five thousand gallons per hour, and it has a temperature ranging from 105° to 110° F. The following analysis was made by Dr. Winslow Anderson in 1889:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	25.73
Sodium bicarbonate	41.19
Sodium carbonate	7.62
Sodium sulphate	7.25
Sodium iodide	Trace.
Sodium bromide	Trace.
Potassium chloride	1.57
Potassium carbonate	2.05
Potassium iodide	Trace.
Potassium sulphate	Trace.
Magnesium carbonate	2.15
Magnesium sulphate	5.11
Calcium carbonate	1.23
Calcium sulphate	2.94
Ferrum peroxide	.73
Borates	Trace.
Lithates	Trace.
Alumina	.25
Silica	1.75
Iodides and bromides	Trace.
Organic matter	1.90
Total	101.47
Gases.	Cu. in.
Free sulphureted hydrogen	3.75
Free carbonic acid gas	8.90

These waters are found to be especially serviceable in subacute and chronic rheumatism and articular affections, in blood, glandular, and cutaneous affections, and in strumous cases. In catarrh of the naso-pharynx the water, used as a hot douche, has proved beneficial. It may also be used to advantage, in the form of a hot douche, in the treatment of leucorrhœal discharges and in engorgement of the female pelvic organs. The mud springs, about a mile and a half north of the hotel, are of decided benefit in rheumatism, arthritis, stiff joints, sprains, synovitis, glandular enlargements, chronic cutaneous diseases, etc. They range in temperature from 104° to 122° F., and have been found to be highly charged with mineral and gaseous ingredients. The mud springs cover a space of about twenty-five feet square, over which suitable bathing facilities have been established. These consist of dressing-rooms, hot sulphurous water plunges, and the mud bath. This latter is a compartment or vat four by eight feet and nearly filled with prepared moor or mud, and so arranged that the hot sulphurous water and gases rise directly into it from the ground beneath. The mud springs flow collectively about six thousand gallons per hour. About two hundred yards north of the mud baths is the Soda Spring. Its temperature is 77° F., and its flow is limited. The water is much used for drinking purposes. By allowing a small quantity of sulphureted hydrogen to escape the water becomes very palatable. According to Anderson's analysis,

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	25.10
Sodium carbonate	7.25
Sodium bicarbonate	19.70
Sodium sulphate	5.05
Potassium carbonate	1.16
Potassium sulphate	.83

Solids.	Grains.
Magnesium carbonate	3.17
Magnesium sulphate	7.80
Calcium carbonate	5.32
Calcium sulphate	6.47
Iron peroxide	Trace.
Silica	.92
Alumina	.85
Organic matter	Trace.
Total solids	83.82
Gases.	**cu. in.**
Free carbonic acid gas	9.20
Free sulphureted hydrogen	1.60

The water has valuable antacid and aperient properties. It belongs to the alkaline-carbonated class. The other springs at Paso Robles are not extensively used as yet, although some of them will no doubt be found of value.

James K. Crook.

EMBALMING. See *Dead Bodies, Disposal of.*

EMBELIA.—The fruit of *Embelia ribes* Burm. (fam. *Myrsinaceæ*). The fruits of this Indian shrub are nearly as large as black-pepper fruits, globular, slightly beaked, dull red and striate, becoming brown on keeping. They are said to be used to adulterate pepper. The drug is largely used in its home as a stomachic, carminative, stimulant, and anthelmintic, and also as a parasiticidal application to ringworm and similar affections. It appears to be specially useful as a tænicide. Although it is said usually to kill the worm, a purgative should be taken both before and after the administration of the remedy. Its important constituent is *embelic acid*, which is found to possess the same properties as the drug itself. Embelic acid, the formula for which is $C_9H_{14}O_2$, occurs in orange-yellow scales, soluble in alcohol, odorless and tasteless. It is given in doses of 0.2 to 0.4 gm. (gr. iij.–vi.), to be both preceded and followed by castor oil. The fruit contains also resin, fat, tannin, and a small amount of an alkaloid, which has been called *christembine*. The powdered fruit is given in doses of from 4 to 16 gm. (ʒ i.–iv.) or the fluid extract in corresponding amount.

Henry H. Rusby.

EMBOLISM.—That form of metastasis in which insoluble substances are transported by the blood current and lodged in some part of the vascular system is known as embolism. The material transported is an embolus. The process may occur in lymph vessels (lymphogenous embolism), as well as in blood-vessels (hæmatogenous embolism). The latter is, however, the more common and important form, and embolism is usually understood to mean this when no special modifying designation is used.

The substances which may enter the vascular system and be carried in the blood stream as emboli are of the most varied character. They may be gaseous, liquid, or solid. The most common emboli are those composed of the products of coagulation of the blood, and unless specially designated an embolus is usually understood to be derived from a thrombus. Tumor cells, living or dead tissue elements, animal or vegetable parasites, parenchymatous cells, placental cells, fat, pigment, masses of calcification, air, and various extrinsic substances may also gain entrance into the blood stream and form emboli.

The lodgment and impaction of the embolus in the vessel is due to the fact that on account of either its size or its physical properties the material transported is caught upon an obstruction in the vessel or cannot pass its lumen, and so remains either partially or wholly blocking it. Metastasis in the direction of the normal current is known as direct embolism, in the opposite direction as retrograde. The transportation of emboli from the veins into the systemic arteries without passing through the pulmonary circulation is designated crossed or paradoxical embolism. This may occur in case of a patent foramen ovale or a persistent ductus Botalli.

The importance of the embolism depends upon the nature of the embolus, its size, and the anatomical location and relation of the obstructed vessel. Emboli containing tumor cells or infective agents, as bacteria, are the most injurious (septic emboli); those consisting of dead tissues or substances incapable of growth act only mechanically in obstructing the circulation (bland or aseptic emboli). Hard or sharp-pointed substances may injure the vessel wall and lead to the formation of an aneurism. Toxic or infective emboli may weaken the wall of the vessel and also produce aneurisms. Large emboli may seriously interfere with the nutrition of the part supplied by the obstructed vessel. Embolism of small arterioles or capillaries may produce a very slight disturbance of nutrition or none at all. If the embolus does not completely occlude the vessel no serious circulatory disturbance may be caused, but the complete closure of the vessel usually follows from the formation of an induced or secondary thrombus. If the obstructed vessel has abundant collateral anastomoses beyond the point of obstruction no disturbance of nutrition of any consequence may occur; but if the obstructed vessel is a terminal artery poorly provided with collaterals, degeneration or necrosis of the part supplied by it will result from an insufficient supply of nutrition (anæmic and hemorrhagic infarction).

Direct Embolism.—Embolism in the direction of the normal blood current is of most frequent occurrence. The substance forming the embolus is carried along by the blood stream until it is caught by some obstruction or swept into a channel so narrow as to prevent its farther passage. It follows, therefore, that direct embolism can occur only in the pulmonary and systemic arteries, heart, and portal vein. Emboli found in the right side of the heart or pulmonary arteries have their origin in the systemic veins; those found in the systemic arteries arise in the pulmonary veins or left heart. Portal vein emboli take their origin from thrombi either in the main trunk or in its contributing branches. The course and site of lodgment of the embolus is determined by the size, form, weight, and character of the material composing it, as well as by the force and volume of the blood stream, the size of the blood-vessels, the angle at which they are given off, the position of the body, etc. Consequently emboli arising in the systemic veins or right heart are more frequently carried into the pulmonary arteries supplying the lower lobes of the lungs, and more frequently into those of the right lower lobe than into those of the left. Emboli from the left heart more frequently pass into the thoracic aorta than into the carotid or subclavian arteries. The left carotid arising from the highest point of the aortic arch is more likely to receive emboli than the right carotid. Likewise the left common iliac artery, being more directly in the line of the current in the abdominal aorta, receives emboli more often than the right iliac. Since the conditions in the systemic veins are much more favorable for thrombosis, embolism of the pulmonary arteries is much more common than of the systemic arteries. Of the latter the small branches in the lower extremities are most likely to receive emboli, but in the great majority of cases this event is not diagnosed clinically, inasmuch as the symptoms produced are of much less importance than those caused by embolism of the renal arteries, splenic, etc.

If the embolus completely closes the lumen of the obstructed vessel, it is styled an obturating embolus. Spherical emboli are most likely to do this, but an elongated portion of a thrombus may be folded several times upon itself and pushed into a vessel several times its own diameter, completely obturating the lumen. This happens very often in the case of long pieces of thrombi washed out of the femoral veins and in this manner blocking up the largest branches of the pulmonary artery. Similarly, irregular thrombi of soft consistence may be pushed into a vessel so as completely to fill it. If the embolus is hard and firm there may still be some space left for the blood to flow, but this is usually soon closed by secondary thrombosis. Cylindrical, elongated, flat or irregular emboli may be caught at an arterial bifurcation and be pushed partly into both branches, either wholly or partly blocking them (straddling or riding embolus).

Large soft thrombi may break up and the resulting emboli may fill a large number of small branches. Emboli arising in the systemic veins small enough to pass the pulmonary capillaries may lodge in the cerebral or renal capillaries.

Retrograde Embolism.—A retrograde transportation and impaction of an embolus is more likely to occur in the lymph stream than in the blood, and plays a very important part in the lymphogenous metastasis of tumors. Under especial conditions retrograde embolism may occur also in the veins, usually in the large veins near the heart. The cause of the retrograde transportation may lie either in a reflux flow from the heart and great veins into the hepatic veins or the veins of the neck, head, or arms; or in case of extreme venous stasis an embolus may be gradually pushed backward in the vein by abnormal venous pulse waves proceeding from the heart. This event is most likely to occur in dilatation of the right heart with tricuspid insufficiency. Any condition which increases the pressure in the veins near the heart favors also a retrograde embolism—decreased negative pressure in the thorax, disturbances of respiration, prolonged and difficult expiration, cardiac insufficiency, etc. If the venous valves remain adequate the embolus may be caught on them, but in the extreme distention of the vessels they become insufficient and allow the embolus to pass. Retrograde metastasis has been observed in the hepatic, cerebral, mesenteric, renal, pulmonary, axillary, and coronary veins, pampiniform plexus, and dural sinuses. It has been most frequently observed in the case of tumor metastasis, but retrograde transportation of liver cells and infective emboli has also been reported. In the case of non-infective thrombotic material it would be very difficult to establish a diagnosis of retrograde embolism.

Paradoxical Embolism.—The passage of emboli through an open foramen ovale or persistent ductus Botalli without passing through the pulmonary circulation is known as paradoxical or crossed embolism. An opening in the foramen ovale in the shape of a narrow oblique slit is found in a relatively large number of autopsies. Under conditions of disturbed pulmonary circulation in which the pressure in the right auricle becomes greater than that in the left, the slit in the foramen is widened and its membranous edges are bulged into the left auricle. The opening may be so enlarged that not only small emboli may pass through it, but thrombi arising in the right side of the heart may extend through it into the left auricle. Masses of tumor cells and liver cells, the latter in cases of traumatic laceration of that organ, have been found obstructing the opening. Aside from such autopsic evidence the diagnosis of crossed embolism is impossible. The metastasis of certain large-celled tumors is best explained by the assumption of paradoxical embolism, but the possibility of even large tumor cells passing through the pulmonary capillaries without setting up lung secondaries must be borne in mind.

VARIETIES OF EMBOLI.—*Bland Emboli.*—These are composed for the greater part of thrombotic material which does not contain toxic or infective agents; but no sharp line can be drawn between them and septic emboli, inasmuch as emboli may contain pathogenetic organisms and yet not give rise to septic processes, because of the action of the protective forces of the body inhibiting their growth. The practical criterion is not the absence or presence of micro-organisms in the embolus but the effect of the latter upon the vessel wall at the point of lodgment. A bland embolus is accordingly one whose effects are purely mechanical. Besides thrombotic material, pigment granules, dead cellular elements, fat, masses of calcification, extrinsic substances such as carbon or metal dust, etc., may produce only mechanical effects.

Infective Emboli.—Because of their frequent occurrence and the serious conditions resulting from them infective emboli containing pathogenetic micro-organisms are of very great pathological importance. In addition to the purely mechanical effects produced by them they show at the point of lodgment the characteristic effects of the bacteria which they contain. These effects are chemical in nature, the result of the specific products of the organism, and are characterized by degeneration or necrosis of the vessel wall, hemorrhages, inflammation, suppuration, gangrene, etc. As a result of the weakening of the wall through the injury or destruction of its inner coat an aneurism may be formed (aneurysma mycotico-embolicum). The metastasis of emboli containing pyogenetic organisms gives rise to the condition known as pyæmia. The primary focus of the embolism is usually an infective venous thrombus formed at the point of entrance of the bacteria, which may be in any part of the body. From this thrombus emboli may arise and convey the bacteria to other parts of the vascular system, where having lodged they may multiply and produce poisons which exert their characteristic effects upon the vessel wall and surrounding tissues. From these secondary foci other emboli may be given off and the process indefinitely repeated.

There may be no evident primary focus and the secondary lesions may form the only features of the disease; or, as in the case of malignant endocarditis, infective thrombi may form upon the valves of the heart and give origin to infective emboli, though the primary entrance of the bacteria into the vascular system cannot be discovered (cryptogenic infection). Embolism of bacteria alone from the primary focus, either singly or in masses, may occur without the formation of an infective thrombus at this point. These may become attached to the vessel wall, multiply, and set up their characteristic changes. In this manner bacteria arising in infective thrombi in the systemic veins may pass the lung capillaries and produce their effects in the systemic arteries or capillaries. As mentioned above, not all emboli containing pathogenetic bacteria give rise to secondary lesions at the point of lodgment. This may be explained by an increase in the vital resistance of the body or a diminished virulence of the bacteria due to conditions arising either in them or in the body.

Tumor-cell Emboli.—Very rarely benign tumors may extend into blood-vessels and give rise to emboli which may develop into secondary growths of the same nature as the primary. In the metastasis of malignant tumors embolism plays a much more important rôle, as it is the chief factor of their spread through the body. Both carcinoma and sarcoma very frequently break into blood-vessels, loosened tumor cells are carried away in the blood stream, and from the emboli thus produced secondary growths arise. It may be emphasized here that this embolism is always one of tumor cells and not of parasites which may cause the formation of such cells. The structure of sarcoma particularly favors hæmatogenous metastasis, inasmuch as the cells of a sarcoma not infrequently form the wall of the blood-vessels of the tumor, or are separated from the blood stream by an endothelial layer only. On the other hand, the spread of carcinoma into the lymph spaces favors lymphogenous metastasis, and in general it may be said that sarcoma and carcinoma are characterized respectively by hæmatogenous and by lymphogenous metastasis. Large masses of tumor cells coming from the systemic veins may block the orifices of the right heart or the pulmonary artery and cause sudden death. As a rule, however, the mechanical effects of emboli composed of tumor cells are unimportant when compared to the significance of the tumor metastasis. More frequently the secondary growths of malignant tumors arise from capillary emboli rather than from those of large size. Tumor cells of small size may pass the pulmonary capillaries without lodgment and give rise to secondary growths in the systemic capillaries. Both the retrograde and the paradoxical varieties of embolism of tumor cells have been observed.

Emboli of Animal Parasites.—The Filaria sanguinis, Bilharzia hæmatobia, and the Plasmodium malariæ may be found in the blood of the human body, and under certain conditions may block the capillaries or smaller arterioles. Echinococcus cysts in the heart wall may rupture into the blood stream and give rise to general metastasis. The embryos of trichina pass from the intestine to the muscles through the lymph and blood, and the amœbæ found in the intestine may reach the liver by way of the portal vein.

Fat Embolism.—This is probably a very common form of embolism, but in the majority of cases it is of little pathological significance. Occasionally it is fatal, in conditions when so much fat is set free into the circulation as to block up many capillaries and small arteries; or a moderate fat embolism may aid in causing death in cases of shock, cachexia, anæmia, etc. The source of the fat is usually the fatty bone marrow, but fat may enter the circulation as the result of injury to any tissue or organ of the body which contains fat. Amputations, fractures, crushing, etc., of bones containing fatty marrow are the most common causes, but even slight concussion of the bones may set free some fat into the bloodvessels. Congestion or inflammation of the marrow may also lead to fat embolism. Injury to adipose tissue in breast amputations, laparotomy during child-birth, laceration or necrosis of fatty liver, destruction of brain tissue, fatty degeneration of sclerotic plaques, etc., may also cause the entrance of fat into the circulation. Fatty embolism has also been observed in the lipæmia of diabetes, and has been supposed to be the cause of the dyspnœa and coma in this disease.

The fat droplets floating in the blood stream collect for the greater part in the lung capillaries, and in severe cases the majority of these vessels may be found greatly distended and filled with plugs of oil. The capillaries of the brain, kidneys, and heart suffer next in proportion. Layers of fat may occasionally be present in the postmortem clots found in the heart and great veins. The results of fatty embolism are purely mechanical. In a moderate degree the fat may be disposed of by saponification, emulsion, phagocytosis, etc.

Cellular Embolism.—Pulmonary embolism of the giant cells of the bone marrow is of very frequent occurrence, being found in many toxic and infective conditions, pernicious anæmia, splenic anæmia, leukæmia, congestion and inflammation of the bone marrow, injury to the bones, etc. It occurs to the greatest extent in puerperal eclampsia, but is also commonly found in the lungs of women dying in the puerperium of diseases other than eclampsia. The significance of the process is not yet known; within a limited degree it may be physiological, or it may occur just before death as a pre-agonal phenomenon. In the acute infections the existing hyperæmia of the bone marrow may be the underlying cause of the metastasis. Injury to the bones may cause a metastasis not only of the fat and giant cells of the marrow but also of portions of marrow tissue and bony fragments. The giant cells appear in the lung capillaries as deeply staining masses of chromatin having a very irregular knobbed shape, rarely multinuclear. As a rule the cells are crowded so tightly into the capillaries that no cell protoplasm can be made out, but in the cells found in the small arterioles the protoplasm is usually intact. In puerperal eclampsia the number of giant-cell emboli may be as great as from six to eight in every low-power field. This variety of embolism is also found in association with other forms of cellular embolism—*e.g.*, that of liver cells, placental cells, etc. Giant cells resembling those of the marrow may originate in the hæmolymph glands in fatal cases of anæmia, and it is possible that these may also give rise to pulmonary embolism.

Giant cells arising from the syncytium of the chorionic villi have also been found in the pulmonary capillaries in cases of puerperal eclampsia, hydatid mole, etc. According to Schmorl, this form of embolism plays an important rôle in the etiology of eclampsia; but this is probably not the case, as it is not constantly found in this disease and may be present in the lungs of puerperal women not suffering from eclampsic symptoms. Further, since the differential diagnosis of multinuclear bone-marrow cells and syncytial cells is practically impossible, it is probable that many of the emboli found in the pulmonary capillaries and thought to be syncytial cells were in reality bone-marrow cells. In case of hydatid moles portions of syncytial buds or villi may break into the uterine sinuses and be carried to the lungs, but this process must be regarded as being of the nature of a tumor metastasis.

After traumatic laceration of the liver, large portions of liver tissue have been found in the pulmonary arteries. Small pulmonary emboli of liver cells may occur after hemorrhage and necrosis of the liver. Paradoxical embolism of liver cells has also been observed, and portions of liver tissue have been found blocking the foramen ovale. In connection with liver-cell embolism pulmonary emboli of bone-marrow giant cells are usually present.

Splenic cells, sometimes containing malarial parasites and pigment, red blood cells, or blood pigment, may be found under certain conditions in the liver capillaries. Portions of endothelium, bits of the heart valves, etc., may also be loosened into the blood stream and form emboli in the capillaries of various organs: brain, spleen, kidneys, etc.

Air Embolism.—Air may enter the circulation through wounds or surgical operations about the neck, upper part of thorax, shoulders and head, in which conditions the air is sucked into open veins by means of respiratory aspiration. Air may also enter the circulation through the uterine veins after separation of the placenta in abortion, placenta prævia, uterine injections, etc.; or open veins in ulcers of the stomach and intestines may be the point of entrance. Gaseous embolism may be produced by infection with gas-producing bacilli. The cause of death in caisson disease has been thought to be emboli of nitrogen which has been absorbed by the blood under high atmospheric pressure and suddenly released on return to normal atmospheric conditions. It is probable that many of the cases reported as air embolism, especially those in which the air has been supposed to enter the uterine or stomach veins, have been in reality cases of gaseous embolism due to infection with the Bacillus aërogenes capsulatus.

Effects of Embolism.—The metastasis of dead or inert substances incapable of growth produces chiefly mechanical effects, inasmuch as their chemical properties are not usually such as to cause further alterations in the vessel wall or its neighborhood. Of the purely mechanical effects the most important is the obstruction of an artery by an embolus. If the embolized vessel has abundant anastomoses, as is the case with the arteries of the voluntary muscles, skin, bone, uterus, thyroid, etc., there may be no appreciable disturbance of the circulation; but if the obstructed vessel has few anastomoses and a collateral circulation is not quickly established, the tissues supplied by the occluded artery will quickly degenerate or necrose as the result of the anæmia. The area of anæmic necrosis produced by the occlusion of an artery by either thrombosis or embolism is known as an infarct. Two varieties of infarcts are distinguished: anæmic or white, and the hemorrhagic or red infarct. The former occurs as the result of the occlusion of terminal arteries in the kidneys, spleen, heart, brain, and rarely in the liver. The hemorrhagic infarct occurs regularly as the result of the obstruction of the terminal branches of the pulmonary and superior mesenteric arteries. It differs from the anæmic only in that into the necrosed area there is an infiltration of blood. It is therefore a hemorrhagic-anæmic necrosis. The hemorrhage into the necrosed tissue takes placed by diapedesis from the injured walls of the vessels lying within or at the border of the infarcted area. These become partly filled with blood from collateral capillaries and arterioles, and the vessel walls, weakened by disturbance of nutrition from the lack of their accustomed blood supply, permit of hemorrhage by diapedesis. The low tissue-resistance in the lung and mesentery and submucosa of the intestines also favors hemorrhage. Surrounding the anæmic infarcts of the spleen, heart, kidneys, etc., there is always a narrow zone of congestion and hemorrhagic infarction which is visible in the fresh specimen as a red line surrounding the gray or yellowish dead anæmic area. This may be explained as being due partly to collateral congestion and partly to hemorrhage from the small anastomosing vessels at the border of the infarct, whose walls also suffer disturbance of nutrition from the anæmia or stasis, and permit the escape of blood by diapedesis. In cases of extreme venous congestion this border-line of hemorrhage may be greatly increased in size and an anæmic infarct may for the greater part or wholly become hemorrhagic. Thrombosis in the veins also favors the production of hemorrhagic infarction. It is probable that under normal conditions of the circulation occlusion of a terminal branch of either the pulmonary or the mesenteric arteries will produce no infarction owing to the rich collateral anastomosis. Under conditions in which the circulation in these vessels is already impaired obstruction of their terminal branches will produce a hemorrhagic infarct. The fact that infarcts of the lung and intestines are invariably hemorrhagic has not yet been satisfactorily explained, but it is supposed that the rich anastomoses of the pulmonary and superior mesenteric arteries lead, through the establishment of a collateral flow, to the refilling of the vessels of the infarcted area, and that the walls of these vessels having been damaged by the anæmia permit of diapedesis.

Embolism of the coronary arteries, the valvular orifices, the pulmonary artery or its main branches, or the bulbar arteries may cause immediate death. Fat embolism of the cerebral, pulmonary, or renal capillaries may be so extensive as to cause death by obstruction of the circulation and disturbances of nutrition. Less severe cases may cause coma, dyspnœa, etc., while moderate degrees may produce no symptoms at all. Likewise air embolism in small amount may produce no effect. Larger amounts of air may collect in the right heart and pulmonary artery in a frothy mass which the heart is unable to force through the pulmonary capillaries, death resulting from paralysis of the heart. In caisson disease death may follow the embolism of bubbles of nitrogen which have been suddenly liberated in the blood by the too sudden reduction of the high atmospheric pressure under which it had been absorbed. The effects of embolism of cellular elements, animal parasites, etc., are purely mechanical. Pulmonary embolism of placental cells has been thought to be the cause of eclamptic convulsions. Tumor cells not only act mechanically but give rise to secondary growths as well. Sharp-pointed masses of calcification, etc., not only cause obstruction of the circulation but may so injure the vessel wall as to lead to the formation of an aneurism.

Toxic and infective emboli, in addition to their purely mechanical effects, produce changes in the vessel wall and its neighborhood due to the action of the poisons which they contain or which are produced by the bacteria contained within them. Degeneration, necrosis, and inflammation of the vessel at the point of obstruction may lead to a widespread purulent arteritis, formation of abscesses, etc., or as a result of the weakening of the wall aneurisms may be produced.

Sequelæ.—In the case of embolism of thrombotic material organization, simple and purulent softening, or calcification of the embolus may take place. The sequelæ of infarction are essentially the same as those of necrosis in general: organization, encapsulation, cyst formation, calcification, abscess, gangrene, etc. Emboli of liver cells quickly necrose, the dying cells forming centres of coagulation and thrombus formation. Bone marrow and placental giant cells undergo a slow necrobiosis, and may also give rise to thrombosis. Small bits of dead tissue, pigment granules, and bacteria may be removed by phagocytes. Fat in small amount is saponified or emulsified, or disposed of by phagocytosis. Small amounts of air may be absorbed.

SYMPTOMS.—The general symptoms of non-infective embolism depend upon the anatomical position and relations of the occluded vessel, the specific function of the part supplied by it, and the degree of anæmia produced by the obstruction. The passage of the embolus through the vessels or heart causes no definite symptoms. Pain may follow the impaction of an embolus in an artery, particularly in the abdominal aorta, mesenteric, iliac, and femoral arteries. At times it is very severe, having the character of that of a painful blow. It is probably due to the irritation of sensory nerves in the vessel wall caused by the sudden impaction and distention. Pain may follow the embolism as a result of local anæmia, inflammation, and the various sequelæ of infarction. In rare cases a chill or fever may accompany the impaction of non-infective emboli. Fever, however, usually follows embolism as one of the accompanying phenomena of secondary inflammation, sepsis, gangrene, etc. Embolism of vessels supplying visible parts of the body may be manifested by signs of local anæmia, gangrene, etc. Infarction of the lungs, kidneys, and intestines may be shown by hemorrhage from these organs. Infarction of any organ will lead to disturbance of its function. In the case of infective emboli, besides the symptoms due to the mechanical obstruction of the circulation, those of local and general infection are present: chills, fever, etc. These are usually of such great importance as completely to cast into the background the symptoms of local anæmia or infarction.

The order of frequency of arterial embolism is given by Welch as follows: pulmonary, renal, splenic, cerebral, iliac and arteries of lower extremities, axillary and arteries of upper extremities, cœliac axis with hepatic and gastric branches, central artery of the retina, superior mesenteric, inferior mesenteric, abdominal aorta, and coronary arteries. This order is based not so much upon the actual occurrence of emboli as upon the symptoms of embolism. It is very probable that embolism of the small arteries of the lower extremities would come next to the pulmonary in the order of frequency, but the signs or symptoms attending this event may be so unimportant as to be overlooked.

Pulmonary Embolism.—Embolism of the main trunk or both of the main branches of the pulmonary artery is usually followed by sudden death from syncope. In other cases there may be a sudden attack of intense precordial pain and dyspnœa followed quickly by death. In less extensive pulmonary embolism the chief symptoms may be intense dyspnœa, cyanosis, great disturbance of heart action and respiration, sweating, chills, syncope, convulsions, coma, etc. Embolism of the smaller terminal branches may produce no symptoms, but very often hemorrhagic infarction is accompanied by chills, dyspnœa, fever, pain in the side, pulmonary hemorrhage, etc. Infective emboli give rise to pyæmic abscesses, purulent and fibrinous pneumonia, and the local and general symptoms arising from these conditions.

Renal Embolism.—Large infarcts of the kidney may cause pain; small ones are unaccompanied by painful sensations. Hæmaturia is the most important sign of renal infarction. Infective emboli cause pyæmic abscesses. These are manifested by severe constitutional symptoms of intoxication, pyuria, etc.

Splenic Embolism.—Infarction of the spleen may occur without signs or symptoms, but frequently there are sudden pain in the splenic region, chills and fever, splenic enlargement, perisplenitic friction, etc. Infective emboli may cause splenic abscess with symptoms of pyæmia.

Cerebral Embolism.—The left middle cerebral is most commonly involved. Sudden hemiplegia and aphasia are the chief symptoms. Embolism of the vertebral or basilar artery produces symptoms of acute bulbar paralysis.

Mesenteric Embolism.—Infarction of the intestines is usually manifested by sudden attacks of severe colicky pain, abdominal tenderness, bloody or fæcal vomiting, blood in the stools, gangrenous odor of stools, sweating, subnormal temperature, and collapse. Death usually occurs within a very short time. Very rarely the symptoms are less pronounced and of such vague character as to make diagnosis impossible. The condition may very much resemble that of intestinal obstruction. Embolism of the smaller branches of the intestinal arteries gives rise to the formation of intestinal ulcers.

Aortic Embolism.—The occlusion of the thoracic aorta by embolism is of very rare occurrence. It may be caused by the dislodgment of large thrombi in the heart or in aortic aneurisms above the point of embolism. Death is instantaneous or occurs within a very short time. Embolism of the abdominal aorta is not of such rare occurrence. In the majority of cases the embolus arises from a heart thrombus. The symptoms may develop suddenly or the onset may be gradual. Pain in both legs, often extreme, is usually present; with this there is associated paralysis, absence of femoral pulsation, and ascending gangrene. Death may occur within a few hours or be delayed for months, in the latter case the result of slowly progressive gangrene or sepsis. Embolism of the iliacs, or of the femoral or popliteal arteries is manifested by similar symptoms varying in degree with the size of the vessel occluded and the location of the embolus.

Coronary Embolism.—Embolism of the larger branches of the coronary arteries causes sudden death, or an attack of extreme dyspnœa and severe precordial pain which may be followed shortly by death. Embolism of the smaller branches may cause anæmic infarction with symptoms of angina pectoris. As a result of the weakening of the heart wall by the infarction rupture of the heart into the pericardial sac may take place causing sudden death, or aneurismal dilatation of the heart may be produced, leading to serious impairment of cardiac efficiency.

Retinal Embolism.—Sudden blindness is produced by the embolic occlusion of the central artery of the retina. Ophthalmoscopic examination reveals a condition of retinal infarction usually without the occurrence of hemorrhage. In embolism of the smaller retinal branches multiple hemorrhages usually occur with more or less pronounced disturbance of vision.

Embolism of Spermatic Artery.—Occlusion of the spermatic artery by embolism is said to have caused gangrene of the testis in a small number of cases.

Diagnosis.—Since the chief symptoms of embolism are of the same nature as those of thrombosis, the differential diagnosis of these two conditions is of main importance. The sudden development and severity of symptoms of arterial anæmia are more characteristic of embolism than of thrombosis. Absolute dependence cannot, however, be placed upon this point, inasmuch as thrombi occasionally occlude with great rapidity, while on the other hand the symptoms of embolism may be slow of development owing to the fact that the embolus either does not entirely obturate the vessel which is later completely closed by secondary thrombosis, or the embolus may be so situated that the secondary thrombosis plays the chief part in the production of the anæmia. After arterial embolism the establishment of the collateral circulation usually leads to a more decided improvement of symptoms than is commonly the case after thrombosis. Absolute reliance cannot be placed upon this factor, since occasionally after thrombosis very marked amelioration follows the development of the collateral circulation. The occurrence of arterial obstruction in young individuals or in adults showing no signs of arteriosclerosis, especially in cases of valvular lesions of the left side of the heart, points very strongly to the occurrence of embolism. If arteriosclerosis is present, the differential diagnosis between thrombosis and embolism becomes much more difficult.

The establishment of a source for emboli in the existence of a previously formed thrombus, cardiac disease, aneurism, infected wound, etc., is the most reliable factor in the diagnosis of embolism. In pulmonary embolism the source may be sought in thrombi in the systemic veins or right heart. In embolism of the systemic arteries the chief source of the embolus is disease of the mitral or aortic valves. Thrombi in aortic aneurisms may also give rise to emboli. Infected wounds, abscesses, acute endocarditis, etc., form the sources of infective emboli. Abortion, separation of the placenta, uterine injections, pregnancy, etc., are conditions in which embolism may occur. Injury of the bones or fat-containing tissues gives rise to fatty embolism. Though cases may occur in which the source cannot be found, and though the existence of a thrombus in one vessel does not exclude the occurrence of thrombosis in others, it is possible, in the majority of cases, to make a correct diagnosis of embolism whenever definite symptoms are present.

Treatment.—Prophylactic treatment may be of the greatest importance in the prevention of the detachment of an embolus from a thrombus. In the case of venous thrombosis of the lower extremities absolute rest of the affected limb, or better of the body as a whole, should be insisted upon, as a very large percentage of the cases of death from pulmonary embolism occur as the result of the patient's movements in walking, bathing, or going to stool. Walking should not be allowed for at least six weeks after venous thrombosis of the lower extremities. Massage or palpation of the affected vein, or even pressure upon it with a stethoscope, as well as all unnecessary movement and manipulation of the limb, should be avoided. Prophylactic measures may be instituted further against the formation of thrombi by stimulation of the heart's action, improvement of the general nutrition, prevention of extension of infection by surgical interference, etc. In the case of acute endocarditis, heart thrombus, aortic aneurism, etc., absolute rest is also essential as a prophylactic measure against embolism.

After embolism has occurred the general indications are relief of pain, absolute rest, proper nourishment, cardiac stimulation, etc. The development of the collateral circulation should be brought about as soon as possible in order to avoid anæmic necrosis. In case of embolism of accessible portions of the body this may be aided by the local application of heat. When infarction has taken place the general indications of treatment are along lines tending to promote absorption and organization of the dead tissues. In the case of gangrene of the lower extremities and intestinal infarction operation according to general surgical principles may be performed.

Aldred Scott Warthin.

EMBRYOLOGY.—The general history of the embryo up to about the end of the second month is given under *Fœtus, Formation of*. The development of special organs is treated under those organs; *e.g.*, for the development of the brain see under *Brain.* There are also included in the Handbook the following special embryological articles: *Allantois, Amnion, Area Embryonalis, Blastoderm, Blastopore, Chorion, Cœlom, Differentiation, Embryos, Gastrula, Germ Layers, Impregnation, Neurenteric Canal, Notochord, Placenta, Proamnion, Segmentation of the Body, Segmentation of the Ovum, Umbilical Cord*, and *Yolk Sac.*

In this article are given, (1) a brief sketch of the history of embryology; (2) practical directions for the study of embryos.

1. History of Embryology.—Although embryology is the department of morphological science now most in vogue among investigators, it has held this high rank but a very short time. Embryology may date its birth, after gestating for many centuries in the womb of science, from the year 1600, when Fabricius ab Aquapendente published his work, "De Formato Fœtu," followed four years later by his "De Formatione Fœtus." After Fabricius came a series of anatomists, who during the seventeenth and eighteenth centuries slowly added to the knowledge of the development of man and other vertebrates; but it was a time of vague general notions, a period when principles which seem to us elementary were still under debate. It was not until Caspar Friederich Wolff published his dissertation, "Theoria Generationis" (1759), that the mere idea of development by gradual differentiation of unformed material could make its way. Wolff is justly regarded as the initiator of modern embryology, for until his views of gradual differentiation (epigenesis) were established correct embryological conceptions were impossible. The next great

advance was due to the influence of Döllinger, of Würzburg, a man who inspired many of the best researches. Under him were trained Pander and von Baer, who first definitely ascertained the existence and traced much of the history of the germ layers. Von Baer was a magnificent intellect—among the great morphologists of Germany easily first. His book (1829) on the development of animals has never been equalled for keen insight and original profound thoughts in the domain of morphology. The author is no less remarkable for his observational powers. Kölliker says, with perfect truth, that von Baer's researches "are to be described as unconditionally the best which the embryological literature of all time and all peoples has to show." The third epoch may be said to have begun with the establishment of the cell doctrine by Schleiden and Schwann (1839), after which began the labor of ascertaining the origin and metamorphoses of the cells in the embryo. Schwann's discovery led to the recognition of the real signification of the segmentation of the yolk, which had been previously discovered. The next great change occurred during 1860–1870, after Darwin had given a mighty impulse to biology by the publication of his "Origin of Species"; in this period the germ layers were discovered and described in invertebrates by Kowalewsky, Metschnikoff, and others, and in the course of a few years it was definitely proved that the germinal layers exist in all multicellular animals. Since 1870 a multitude of researches have been carried out, a wealth of new discoveries made, largely in consequence of the vast improvements in the methods of investigation. These improvements have been—first, in regard to the means of preserving ova and embryos; second, in the manners of making sections and staining them.

Of recent writers the student of human embryology must place His and Kölliker first; the former has worked out the anatomy of very young human embryos with surprising skill, and the latter has contributed a vast series of observations on the development of nearly every organ and tissue.

In the history of embryology, then, the following points mark the chief epochs:

1759.—The doctrine of gradual development, or epigenesis, definitely established by Caspar Fr. Wolff.

1829.—The existence of the germ layers demonstrated, and their most important metamorphoses in vertebrates traced out by Carl Ernst von Baer.

1839.—The cell doctrine applied to animals by Schwann, and embryology turned into the study of histogenesis.

1860–70.—The presence of germ layers in invertebrates proven by Kowalewsky, Metschnikoff, and others.

1870–85.—Constantly increasing number of special researches, and steady perfecting of methods.

2. Embryological Methods.—The student of human embryology cannot obtain his material at will, but can only take advantage of opportunity. A considerable number of abortions and miscarriages, natural and procured, occur in every community, and the ova and embryos thus discharged are, in a minority of cases, normal and fresh; the older the embryo the more likely it is to be in good condition. Embryos less than two inches long are best preserved intact; larger embryos are much better opened, and the parts severed and hardened separately. If the specimen is intended only for the study of gross anatomy, it will suffice to preserve it in seventy-per-cent. alcohol, which must, however, be renewed once or twice at first, and the larger the specimen the more necessary is the caution of changing the alcohol.

If the specimen is good enough to be used for section cutting, it must be preserved with more care. Embryos of more than seventy days should be opened and partially dissected if good preservation of the internal parts is desired. (*a*) For general use Parker's fluid (formalin 16 c.c., water 784 c.c., and 96-per-cent. alcohol 1,200 c.c.) may be recommended, as it has great penetrating power; it should be renewed after twenty-four and forty-eight hours, and the quantity of fluid should be about ten times the volume of the embryo. (*b*) For embryos of nine weeks or less preservation intact in Zenker's fluid (corrosive sublimate, 10 gm., potassium bichromate 5 gm., sodium bisulphate 2 gm., water 200 c.c., glacial acetic acid 10 c.c.) or in von Rath's fluid (saturated solution of picric acid 100 parts, hot saturated solution of corrosive sublimate 100 parts, acetic acid 1 part) may be recommended. Zenker's fluid requires from twelve to thirty-six hours, von Rath's from one-half to two hours, according to the size of the specimen. Both of these require to be followed by treatment with tincture of iodine to remove the corrosive sublimate. (*c*) Of all good methods the most expeditious is to place the embryo or organ for five minutes or less in a mixture of 10 parts strong nitric acid and 90 parts water; transfer to sixty per cent. for an hour or two, and then to seventy per cent. (*d*) The simplest method of all is to put the specimen into sixty-per-cent. alcohol for twenty-four hours, then permanently in seventy to eighty per cent.

In preserving embryological material observe the following rules: Handle the specimen as little as possible; do not on any account put it in water or wash it; if it is necessary to keep it moist, wrap a soft damp cloth gently round it; never put a fresh specimen in strong alcohol; never keep a specimen in strong alcohol, *i.e.*, over eighty per cent. The only time when strong alcohol can be safely used is after a specimen has been hardened; and then only to act for twenty-four hours immediately before embedding.

To cut sections: For very small objects, paraffin is satisfactory, but for most of the work of the human embryologist celloidin is the best embedding material. A specimen to be embedded in this material is put (1) for one day in ninety-five-per-cent. alcohol; (2) for one day in a mixture of equal parts ether and ninety-five-per-cent. alcohol; (3) for one day in a thin celloidin solution; (4) embedded in celloidin. To embed, wrap a piece of glazed paper round a *cylindrical* cork, so as to make a paper cup of which the end of the cork forms the bottom; the paper may be fastened to the cork with a couple of pins; the cup must be considerably deeper than the object to be embedded, because bubbles form in the celloidin, and it is desirable to have the celloidin so deep that the bubbles will rise above the specimen; the specimen is placed in the cup, which is then filled with thick celloidin solution. The object may then be pushed into the right position for cutting. The cup is allowed to stand until a film is formed over the celloidin, and is then (5) transferred to a jar of eighty-per-cent. alcohol, where it remains until the celloidin is thoroughly hardened, a process requiring several days. To keep the cork down and the cup right side up, put into the bottom of the cork a sinker made of a heavy bullet and a stout pin or sharp-pointed wire nail. Celloidin is made by Schering, at Berlin, and sold in ounce boxes; it may be dissolved in equal parts ether and alcohol; two solutions are required, one about the consistence of maple syrup, the other like thick molasses.

Celloidin sections must be made under alcohol. The sections are stained and the celloidin is left on; to mount them, place the sections in alcohol on a glass slide, drain off the extra alcohol, and drop on top of the sections a thin filtered solution (fifteen per cent. is good) of white shellac, enough completely to cover the sections; dry the slide at a gentle warmth, say 30° C., until the shellac is hard; clear up with oil of cloves, and mount in balsam. (This method is new, and has not been published before.)

Staining: Small pieces, not exceeding one-fourth of an inch in diameter, may be stained *in toto* before embedding. The best method, on the whole, because the safest, for *in toto* coloration, is to soak the object for one to two days in alum-cochineal, made by boiling seven parts powdered cochineal and seven parts burnt alum with four hundred parts water for at least one-half hour; the solution must be filtered before using. For staining, Mayer's paracarmine and Mayer's hæmatein solutions may also be highly recommended. For sections it is best to employ a variety of stains; my own experience has led me to consider the following five dyes the most valuable: alum-cochineal, Beale's carmine, Minot's picric acid carmine, alum-hæmatoxylin (Boehmer's), and Weigert's acetate of copper and hæmatoxylin. Osmic acid, nitrate of silver, chloride of gold, etc., must, of course, be used for special purposes, and their employment will naturally suggest itself to the experienced histologist at the proper moment.

Both for the sake of comparison and on account of the rarity of young human embryos, and of the impossibility of obtaining the earlier stages of man's development, it is important to study the embryology of mammals and other vertebrates. An admirable guide for such studies is Sedgwick's edition of Foster and Balfour's "Embryology." The best *résumé* of the methods used in embryology is Lee's "Microtomists' Vade Mecum," of which the German edition edited by Paul Mayer is the best. *Charles Sedgwick Minot.*

EMBRYOS, HUMAN.—AGE.—It has been quite generally accepted that the age of an embryo must be determined by the time of a certain cohabitation. In many cases it was attempted to locate the day exactly. After it had been shown that the ovum is extruded from the ovary at or before menstruation begins, it was then generally admitted that the egg could be fertilized at any point between the ovary and the uterus. The time required for the ovum to pass through the Fallopian tube was considered the time in which it was capable of being fertilized. According to the above, these conclusions are not based on a sound footing, because of the difficulty in obtaining accurate observations, and also because they do not agree with the results obtained from the lower animals. Both Coste and His have shown that the eggs of the hen are fertilized ten or more days after copulation, and the former has shown that the egg is no longer capable of fertilization after it has passed through the lower portion of the oviduct.

Impregnation is nearly always marked by a cessation of menstruation, and it now remains to be shown whether the fertilization takes place during the last menstrual period, or at the time of the first cessation; for it is known from the examination of the ovary in the living subject that ovulation usually comes just before menstruation. Since it seems to be necessary to fertilize the egg just as it leaves the ovary, it is probable that impregnation takes place just before the menstrual period. To locate the menstrual period, from which to compute the age of an embryo, we must consult the tables, which are in part copied from His.

From a comparative standpoint we can easily determine the age of human embryos within four weeks. Counting from the last menstrual period, it is quite easy to see by the size of the embryo whether or not it is, say three or seven weeks old. The table shows that, by counting in this way, embryos of the same size may have a difference of four weeks in age (see Table II., 2, and Table III., 8, 10 and 14). In these cases the age corresponds to the other cases, if from their time twenty-eight days are subtracted. This already indicates that, as a rule, fertilization of the ovum takes place during the ovulation which precedes the first menstruation which has lapsed. After Reichert had shown that menstruation is only a method of clearing out the uterus after an ovulation, and after Leopold had shown that the mucous membrane of the uterus undergoes histological changes before ovulation, it is fair to assume that the latter changes are only preparatory to the reception of the ovum, and that when the unfertilized ovum reaches the uterus, menstruation is only a method of reducing the uterus to its former condition.

Only in four of the cases is it necessary to compute the age of the embryo from the last menstrual period, and it is not fair to assume that just these four embryos have grown too rapidly. All the rest must have twenty-eight days subtracted from their time in order to make them correspond with the above four. These are the main reasons for assuming that the fertilization of the egg takes place just before the first menstrual period which has lapsed. It may be that a great many fertilizations take place during the last menstrual period, but that when menstruation has once begun, the activity of the uterus destroys the ovum, and that, as a rule, only those ova are preserved in which menstruation does not follow the last ovulation. At least the embryological evidence speaks for this, and at present embryologists make their specimens correspond with one another when they reckon their ages from the last menstrual period, minus twenty-eight days.

The tables show, in addition, that in certain pregnancies the first cohabitation followed the last menstrual period. It cannot be that in these cases the ovum of the last period could have been fertilized, for it is quite certain the ovum loses its power of being fertilized shortly after it leaves the Graafian follicle. In the case given in Table III., 1 (B B), the first cohabitation of a newly married woman took place on April 4th, say about five days after the last menstrual period; and the woman ceased menstruating at once, probably on account of the fertilization of the ovum of the following ovulation. If all the cases of newly married women in which there was an early pregnancy were collected, it would, no doubt, be shown that in many of the cases the women did not menstruate at all after marriage. At present, however, I know of four such cases. His has tabulated cases given by Hasler, in which the first copulation, the last menstrual period, and the date of birth of the child are given. In all of these cases the age of the fœtus is from two hundred and seventy to two hundred and eighty days, if the beginning of pregnancy is reckoned from the beginning of the first period which has lapsed. If the beginning of pregnancy is placed at the first cohabitation, the age of the fœtuses varies fully a month according to the time of the cohabitation; if the time which has elapsed between the cohabitation and the first menstruation which lapsed is subtracted from the duration of the pregnancy, then the lengths of the pregnancies are practically alike. Assuming that the lengths of pregnancies should be about the same, it makes it highly probable that fertilization takes place at the time of the first menstrual period which has lapsed rather than at the time of cohabitation.

In several of the cases given in the tables, the last cohabitation took place several weeks before the cessation of menstruation, showing that the vitality of the spermatozoa within the female organs lasts for at least a few weeks. It is probable, however, that the spermatozoa cannot live in the Fallopian tubes or uterus for over a month, because authentic posthumous births always take place within two hundred and eighty days after the father's death.

The general conclusions formulated by Professor His, and accepted by embryologists, are as follows:

1. The beginning of development is the time of impregnation, *i.e.*, at that moment when the spermatozoön enters the ovum.
2. The time the egg leaves the ovary is marked by menstruation, but it is not necessary for the Graafian vesicle to rupture during menstruation; it may take place two or three days before or even during the hemorrhage.
3. The egg is not capable of being fertilized at any point from the ovary to the uterus, but only shortly after it has left the ovary; as a rule, as it is entering the Fallopian tube.
4. The spermatozoa which have entered the female sexual organs must await the ovum in the upper part of the Fallopian tube, and can retain their vitality here several days, or possibly several weeks. The time of cohabitation is, therefore, not directly related to the age of the embryo.
5. The age of the embryo is to be estimated from the beginning of the first menstrual period which has lapsed, although it is possible to have a menstruation after fertilization of the ovum.

6. The age of an embryo can be expressed by the following formula: A = X − M or A = X − M − 28, in which X is the date of the abortion and M the beginning of the last period. The second formula is for embryos in which it is necessary to estimate the age by counting from the first lapsed period.

PRESERVATION.—The human embryos which come into the hands of the embryologists are nearly altogether worthless for careful study, due to careless preservation. Of one-hundred and fifty embryos less than six weeks old, which have come into the writer's hands during the past few years, only a few have proved to be valuable, and these came from two physicians. The main reason why specimens are destroyed, in nearly all cases, is that the ovum is placed in very dilute alcohol, and in so doing it is also handled very roughly. Yet poor specimens are better than none at all, and in all cases all ova should be preserved, even if there is but little hope for a good specimen. Not only should ova which appear to be normal be preserved, but all specimens, for frequently patholog-

TABLE I.—EMBRYOS OF THE SECOND WEEK.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	Peters	0.19 mm.	0.19 mm	3.0 × 1.5 × 1.5 mm.	30 days.		Einbettung des mensch. Eies, 1899.
2	Breuss			5.0 mm	38 days.	10 days.	Wiener med. Wochenblatt, 1877.
3	Reichert			5.5 × 3.3 mm	42 days.	14 days.	Abhandl. d. k. A. d. Wiss., Berlin, 1873.
4	Siegenbeek van Heukelom.	0.325 mm.		5.5 × 4.5 mm			His' Archiv, 1898.
5	Graf Spee	0.37 mm.	1.08 × 1 mm	7.0 × 5.5 mm	5 weeks.	12 days†.	His' Archiv, 1896.
6	No. XI.*	0.8 mm.	1.5 × 1 mm	10.0 × 7.0 × 7.0 mm.	41 days.	13 days.	Dr. Kittredge, Nashua, N. H.
7	Keibel	1.0 mm.		8.5 × 7.75 × 6 mm.			His' Archiv, 1890.
8	Eternod	1.3 mm.		10.8 × 8.2 × 6 mm	34 days.		Anat. Anz., xv., 1898.
9	Graf Spee	1.54 mm.	1.8 × 1.5 mm	10.0 × 8.5 × 6.5 mm.	5 weeks.	12 days†.	His' Archiv, 1896.
	Average	0.79 mm.	1.14 × 1.2 mm	7.2 × 5.8 × 5.4 mm.		12 days.	

* The Roman numbers refer to the embryos in my collection.

† Twelve days in my estimation, as Graf Spee only in a general way gives five weeks as the time between the last period and the abortion.

TABLE II.—EMBRYOS OF THE FIRST HALF OF THE THIRD WEEK.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	No. XII	2.1 mm.	1.5 × 1 × 1 mm	18.0 × 18 × 8	41 days.	13 days.	Dr. Ellis, Elkton, Md.
2	Thomson	2.1 mm.	2.6 mm	5.7 mm	42 days.	14 days.	Edin. Med. and Surg. Journal, 1839.
3	His (E.)	2.1 mm.	2.3 × 1.6 mm	8.5 × 5.5 mm			Anat. mensch. Embryonen.
4	Eternod	2.12 mm.	3.0 × 2.5 × 1.75 mm.	16.3 mm			Anat. Anz., XV., 1898.
5	His (Lg.)	2.15 mm.	1.6 × 1.2 mm	15.0 × 12.5 mm	40 days.	12 days.	Anat. mensch. Embryonen.
6	His (S. R.)	2.2 mm.	1.9 × 1.5 mm	9.0 × 8 mm			Anat. mensch. Embryonen.
7	His (Sch.)	2.2 mm.	2.1 × 1.7 mm				Anat. mensch. Embryonen.
8	His (L.)	2.4 mm.		9.0 × 8 mm			Anat. mensch. Embryonen.
9	Thomson	2.5 mm.	2.1 mm	15.0 × 10 mm	14 days.	14 days.	Edin. Med. and Surg. Journal, 1839.
10	Chiariugi	2.6 mm.	1.9 × 1.8 × 1.6 mm.	15.0 × 12 × 8 mm			Arch. Ital. de. Biol., 12.
11	His (M.)	2.6 mm.	2.6 × 1.7 mm	8.0 × 7.5 mm			Anat. mensch. Embryonen.
12	Graf Spee	2.69 mm.	2.5 × 1.5 mm	15.0 × 14 mm	42 days.	14 days.	Verein. Schles.-Holst. Aerzte, 1887.
13	His (E. B.)	3.0 mm.			42 days.	14 days.	His' Arch., 1896, p. 58.
14	Janósik	3.0 mm.	2.5 mm	8.0 mm	43 days.	15 days.	A. f. m. A., 30.
	Average	2.41 mm.	2.22 × 1.6 × 1.45 mm.	11.7 × 10.6 × 8 mm.		14 days.	

TABLE III.—EMBRYOS OF THE SECOND HALF OF THE THIRD WEEK.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	His (B. B.)	3.2 mm.	3.0 × 2 mm	14 × 11 mm	48 days.	20 days.	Anat. mensch. Embryonen.
2	No. LXXXVII	4.0 mm.		24 × 16 × 9 mm.	42 days.	14 days.	Dr. Cole, Peru, Ill.
3	Ecker	4.0 mm.			45 days.	17 days.	His' Archiv, 1880.
4	His (III.)	4.0 mm.	3.0 × 2.7 mm	30 × 25 mm	51 days.	23 days.	Anat. mensch. Embryonen.
5	His (Lr.)	4.2 mm.	2.8 × 2.3 mm	15 mm			Anat. mensch. Embryonen.
6	Stubenrauch (K.)	4.3 mm.			52 days.	24 days.	Inaug. Dis., München, 1889.
7	No. CXLVIII	4.3 mm.		17 × 14 × 10 mm.	38 days.		Dr. Hoen, Baltimore.
8	Wagner	4.5 mm.			20 days.	20 days.	Müller's Archiv, 1835.
9	No. I	4.5 mm.		30 × 30 mm.			Dr. Gavin, Baltimore.
10	Hensen	4.5 mm.			21 days.	21 days.	His' Archiv, 1877.
11	No. LXXVI	4.5 mm.	3 mm	22 × 20 mm.			Dr. Mitchell, Chicago.
12	No. LXXX	5.0 mm.	4 mm	24 × 18 × 8 mm.			Dr. Branham, Baltimore.
13	His (D 2)	5.0 mm.	4 mm	20 × 15 mm.			Anat. mensch. Embryonen.
14	His (W.)	5.0 mm.		25 × 20 mm.	21 days.	21 days.	Anat. mensch. Embryonen, pp. 7, 74.
15	His (R.)	5.0 mm.		22 mm.			Anat. mensch. Embryonen.
16	Meyer	5.25 mm.	4 mm	22 mm	18 days.	18 days.	A. f. m. A., 36.
17	No. XIX	5.5 mm.	2.5 × 2 × 2 mm	18 × 14 mm.			Dr. Williams, Baltimore.
18	No. XVI	6.0 mm.		24 × 18 mm.			Dr. Sherwood, Baltimore.
19	Stubenrauch (I.)	6.0 mm.			45 days.	17 days.	Inaug. Dis., München, 1889.
	Average	4.67 mm.	3.3 × 2.2 × 2 mm	22 × 18 × 9 mm		19 5 days.	

Table IV.—Embryos of the Fourth Week.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	No. CXVI	6.5 mm.		28 × 20 × 10 mm.	55 days.	27 days.	Dr. Ryan, Springfield, Ill.
2	No. II	7.0 mm.	7.0 × 4.5 × 4.5 mm	25 × 25 mm.	52 days.	24 days.	Dr. C. O. Miller, Baltimore.
3	Stubenrauch (II.)	7.0 mm.			51 days.	23 days.	Inaug. Dis., München, 1889.
4	No. XVIII	7.0 mm.		18 × 18 mm.			Dr. Douglas, Nashville, Tenn.
5	His (B.)	7.0 mm.	4 mm	25 × 22 mm.			Anat. mensch. Embryonen.
6	His (Stt.)	7.75 mm.		21 × 17 mm.	57 days.	27 days.	Anat. mensch. Embryonen, 8, 74.
7	His (XVII.)	8.5 mm.		20 × 12 mm.			Anat. mensch. Embryonen.
8	Meyer	8.0 mm.	5 mm.	45 mm.	28 days.	28 days.	A. f. m. A., 36.
	Average	7.34 mm.	5.3 × 4.5 × 4.5 mm.	26 × 19 × 10 mm.		26 days.	

Table V.—Embryos of the Fifth Week.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	Ecker	10.0 mm.			60 days.	32 days.	Icon. Physiol., 28.
2	No. LXXXVIII	10.0 mm.	4.0 mm	30 × 28 × 15 mm			Dr. Brumm, Detroit.
3	His (XCVIII.)	10.3 mm.		35 × 25 mm			Anat. mensch. Embryonen.
4	No. CIX	11.0 mm.		30 × 30 mm.			Dr. Cushing, Baltimore.
5	His (Br.)	11.0 mm.	5.0 × 4.5 mm	30 × 27 mm.	61 days.	33 days.	Anat. mensch. Embryonen.
6	His (XCVII.)	11.0 mm.		30 × 25 mm.			Anat. mensch. Embryonen.
7	His (Rg.)	11.5 mm.	5.5 × 4.5 mm	30 × 27 mm.			Anat. mensch. Embryonen.
8	His (Sl.)	12.5 mm.	6.0 × 5 mm	30 × 27 mm.			Anat. mensch. Embryonen.
9	His (XIX.)	12.8 mm.	5.0 × 4.5.	40 × 32 mm.			Anat. mensch. Embryonen.
10	No. XXXV	13.0 mm.			37 days.	37 days.	Dr. C. O. Miller, Baltimore.
11	His (M. 2)	13.0 mm.			64 days.	36 days.	Anat. mensch. Embryonen.
12	His (Br. 2)	13.6 mm.	6.0 × 4.5 mm	35 × 28 mm.	63 days.	35 days.	Anat. mensch. Embryonen, 9, 74.
	Average	11.6 mm.	5.2 × 4.6 × 4.5 mm.	32 × 27 × 15 mm.		34.6 days.	

Table VI.—Embryos Over Five Weeks Old.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	His (Dr. 1)	15.0 mm.	6.0 × 5.5 mm	45 × 40 mm.			Anat. mensch. Embryonen.
2	His (S. 2)	15.0 mm.	5.5 × 4.5 mm	35 × 28 mm.			Anat. mensch. Embryonen.
3	His (Lhs.)	17.0 mm.			51 days.		Anat. mensch. Embryonen.
4	No. CVI	17.0 mm.			54 days.		Dr. Gardner, Baltimore.
5	No. XVII	18.0 mm.		40 × 30 × 20 mm.			Dr. Cottrell, Louisville, Ky.
6	No. XLII	18.0 mm.		35 mm.			Dr. Wills, Los Angeles, Cal.
7	No. CXLIV	18.0 mm.		40 × 30 × 30 mm			Dr. Watson, Baltimore.
8	No. V	18.5 mm.		40 × 30 mm			Dr. Kittridge, Nashua, N. H.
9	No. XXVIII	19.0 mm.		50 × 30 × 20 mm	47 days.		Dr. Sewall, Denver, Col.
10	No. LXXXI	20.0 mm.		65 × 55 × 35 mm			Dr. Branham, Baltimore.
11	No. XCIV	20.0 mm.		50 × 40 × 30 mm.			Dr. Knill, Detroit, Mich.
12	No. XXII	20.0 mm.	5.0 × 2 × 2 mm	35 × 30 × 30 mm			Dr. Snively, Waynesboro, Pa.
13	Minot	22.0 mm.			53 days.		Minot's Embryology, 392.
14	His	22.0 mm.			56 days.		Anat. mensch. Embryonen.
15	No. LVII	23.0 mm.		30 mm			Dr. Howard, Cleveland, Ohio.
16	His (Wt.)	23.0 mm.		55 × 50 mm.			Anat. mensch. Embryonen.
17	No. LXXII	23.0 mm.		40 × 30 mm.			Dr. Arthur, Baltimore.
18	No. XXVII	23.0 mm.		30 mm.			Dr. Thayer, Baltimore.
19	His (Lp.)	23.0 mm.		55 × 50 mm.			Anat. mensch. Embryonen.
20	No. XXXI	24.0 mm.		50 × 30 × 30 mm	66 days.		Dr. Ballard, Baltimore.
21	No. VI.	24.0 mm.			77 days.		Dr. C O. Miller, Baltimore.
22	No. CXXVII	24.0 mm.		60 × 45 × 40	84 days.		Dr. A. T. Gundry, Baltimore.
23	No. CXXVIII	24.0 mm.		50 × 40 mm.	76 days.		Dr. Lupton, Baltimore.
24	No. CXVIII.	25.0 mm.			94 days.		Dr. Booker, Baltimore.
25	His. (Dr. 2)	25.0 mm.		45 × 40 mm			Anat. mensch. Embryonen.
26	No. XCIX	27.0 mm.		40 mm	75 days.		Dr. Carr, Durham, N. C.
27	No. XLV	28.0 mm.		40 × 35 × 20 mm.			Dr. Douglas, Nashville, Tenn.
28	No. XXVI	30.0 mm.			75 days.		Dr. Simon, Baltimore.
29	Minot	32.0 mm.			68 days.		Human Embryology, 398.
30	No. LXXIX	32.0 mm.		50 × 50 × 50 mm	91 days.		Dr. Briggs, Blackville, S. C.
31	No. CXXIX	32.0 mm.			65 days.		Dr. Gundry, Baltimore.
32	No. CXLV	33.0 mm.		60 × 50 × 40 mm	78 days.		Dr. Watson, Baltimore.
33	No. LII.	33.0 mm.		40 × 30 × 15 mm.			Dr. Gavin, Baltimore.
34	No. XCVI	44.0 mm.			84 days.		Dr. Spencer, San Francisco.
35	No. XCV	46.0 mm.		68 × 50 × 50 mm	83 days.		Dr. Watson, Baltimore.
36	No. CV	48.0 mm.			83 days.		Dr. Watson, Baltimore.
37	No. XXX	60.0 mm.			77 days.		Dr. Snively, Waynesboro, Pa.
38	No. XCII	70.0 mm.			90 days.		Dr. Ballard, Baltimore.
39	No. XLIX	70.0 mm.			65 days.		
40	No. XXIII	70.0 mm.			65 days.		Dr. Snively, Waynesboro, Pa.
41	No. XXXIV	80.0 mm.			104 days.		Dr. Ellis, Elkton, Md.
42	No. CXLVI	95.0 mm.			115 days.		Dr. Watson, Baltimore.
43	No. CXVII	100.0 mm.			101 days.		Dr. Ballard, Baltimore.
44	No. CXXXVIII	112.0 mm.			127 days.		Dr. Watson, Baltimore.
45	No. CXLIX	130.0 mm.			125 days.		Dr. Hoen, Baltimore.
46	No. XCVIII	160.0 mm.			125 days.		Dr. Atkinson, Baltimore.
47	No. XLVI	135.0 mm.			143 days.		Dr. Taylor, Baltimore.
48	No. CXXI	210.0 mm.			190 days.		Dr. Ballard, Baltimore.

TABLE VII.—EXTREME AND AVERAGE MEASUREMENTS IN MILLIMETRES OF THE EMBRYO AND ITS APPENDAGES, AS OBTAINED FROM TABLES I. TO VI.

Week.	Measurement.	Length of embryo.	Greatest dimensions of the umbilical vesicle.	Greatest dimensions of the chorion.	Probable age in days.
Second	Extreme *	0.19 to 1.54	0.19 to 1.8	3 to 10	10 to 14
	Average	0.79	1.14	7.2	12
First half of third	Extreme	2.1 to 3	1.5 to 3	5.7 to 18	12 to 15
	Average	2.41	2.22	11.7	14
Second half of third	Extreme	3.2 to 6	2.5 to 4	14 to 30	14 to 23
	Average	4.67	3.3	22	19.5
Fourth	Extreme	6.5 to 8	4 to 7	18 to 45	23 to 28
	Average	7.34	5.3	26	26
Fifth	Extreme	10 to 13.6	4 to 6	30 to 40	32 to 37
	Average	11.6	5.2	32	34.6
	Extreme	15 to 19	5.5 to 6	35 to 50	
	Average	17.3	5.7	41	
	Extreme	20 to 24	....	30 to 65	
	Average	22.5	....	47	
	Extreme	25 to 28	....	40 to 45	
	Average	26	....	42	
	Extreme	30 to 48	....	40 to 68	
	Average	37	....	54.5	

* The extreme measurements of the umbilical vesicle and chorion are the greatest measurements in each case.

ical specimens are obtained which may prove to be of the greatest practical value. *The best and most convenient method of preserving young embryos is to place the unopened ovum, with the least possible handling, in a large quantity of very strong alcohol.* The alcohol of druggists is in no case too strong, and, according to my experience, is as a rule too weak. Often the ovum is wrapped in a towel and then placed in a small quantity of alcohol and water. This may be a method of preserving museum specimens, but it practically ruins every embryo which is preserved in this way. When an ovum is placed in, say, four ounces of strong alcohol, the water of the ovum dilutes the alcohol to a proper strength.

Those physicians who have the proper opportunities should place the specimen as soon as possible, and without opening the ovum, in seventy-per-cent. alcohol, *i.e.*, absolute alcohol reduced by volume to seventy per cent. At the end of a day or two it should be placed in fresh alcohol of the same strength. An excellent method for preserving embryological specimens is to place the membranes, blood and all in a weak solution (five to ten per cent.) of formalin.

A second convenient method is to place a specimen in quite a large quantity of Müller's fluid, to be changed once or twice during the first few days, after which it may be preserved in the same fluid indefinitely. The embryo is fully hardened in about a month, and then it can be washed in water for a day or two, after which it is to be preserved in seventy-per-cent. alcohol.

Ten per cent. nitric acid is a convenient and a most excellent method. The ovum is to be placed in four or six ounces of a ten-per-cent. solution and opened while in the fluid, care being taken not to injure the embryo. According to its size (if not over an inch long), it should remain in the acid for from thirty minutes to two hours. At the end of this time it is to be placed in seventy-per-cent. alcohol.

Another excellent method is to employ saturated aqueous corrosive sublimate. The specimen is to be treated as in the ten-per-cent. HNO_3, only it is to remain in the sublimate longer. These specimens are then to be preserved in seventy-per-cent. alcohol.

There are many other methods, but if any of the above are employed there will be a sufficient supply of material to aid the study of human embryology. It is really wonderful to see what progress has been made in this study when we consider how difficult it is to obtain good material. Some of the most important discoveries have been made in the careful study of a few well-preserved human embryos, as a glance at the many papers of His and at the excellent text-book of Minot will show.

A great work is done when the specimens are once obtained, but in order to make it complete they must be placed in the hands of a specialist, who can devote all his energies as well as all the additional necessary expense to these the most precious of embryological specimens.

Franklin P. Mall.

EMBRYOS, HUMAN, PATHOLOGICAL.—This article is based upon the study of fifty pathological human ova which have been collected by me during the past six years. All of the embryos, with but one exception, have been cut into serial sections, thus permitting of a more careful study than is possible from that of the external appearances alone. As far as possible, I have obtained additional data from the physicians who sent me the specimens; these have proved to be of much value in determining the age of them. Sections were also made of the uterine moles, as well as of nearly all of the embryonic membranes sent me. It is almost needless to state that while I was collecting the pathological specimens a considerably greater number of normal ones came into my possession. These have also been cut into serial sections, and they have been constantly used for comparison in studying the pathological ova.

The material at my disposal justifies a much more extensive account than I give. The illustrations could also, with advantage, be much more numerous. In the present article, my aim is to describe in a connected way the specimens as briefly as possible.*

The scattered literature relating to pathological human embryology is very extensive, and in general of not much value. From the numerous communications relating to young pathological embryos, two groups of papers stand out prominently—those of His and those of Giacomini. The more general article by His is published in Virchow's "Festschrift," vol. i., and that by Giacomini, is in Merkel und Bonnet's "Ergebnisse der Anatomie," vol. iv. The results of these two authors I have used as a basis after confirming many of their statements. In general, I am able to confirm all of His' statements, while I find some of Giacomini's obscure. Giacomini's numerous publications are mostly on single specimens, which are usually very young. The nature of his problem, as well as the limited amount of material at his disposal, is a sufficient excuse for any misinterpretation he may have made. His latest paper,[1] published shortly before his death, shows the marked influence the studies of the normal, by Graf Spee and others, have had upon his ideas.

Any change which may take place in the embryo after it is well formed, that is, after the second week, is easily recognizable, provided it has not gone too far. Specimens of this sort can be divided into two great groups:

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* A more detailed description of the embryos referred to will be found in an article by me in the Welch "Festschrift," and in Johns Hopkins Hospital Reports, vol. ix.

(1) those in which the embryo is primarily affected and (2) those in which the chorion is primarily affected. In the first group the embryo is affected and the chorion normal, while in the second group the chorion is diseased and the embryo partly or wholly strangulated, due to its impaired nutrition. The earliest stages, His' nodular forms, are among the most interesting. Since all of them are vesicular, it might be better to call them vesicular forms. In all of them there is a vesicle which shows many of the characteristics of the umbilical vesicle with blood islands embedded within its walls. The fact that the blood and the blood-vessels arise in the umbilical vesicle makes it very certain that the vesicular forms represent the remnants of very early embryos. There have now been studied a sufficient number of young normal embryos to establish the time the blood-vessels grow from the embryo to the chorion. This is at the end of the second week, and the vesicular forms must represent embryos younger than two weeks, for in none of them have the blood-vessels reached the villi of the chorion. Between the time of the formation of blood in the walls of the umbilical vesicle and that of their growth into the chorion lies the important stage of the formation of the body of the embryo. Early normal specimens which Peters,[2] Eternod,[3] Siegenbeek van Heukelom[4] and Graf Spee[5] have recently published indicate that the vesicular stages are formed before the body of the embryo is outlined, and also in many instances hand-in-hand with the formation of the amnion. If we can use the same reasoning with the vesicular forms which we do with the older ones, then the vesicular must be due to arrested development of earlier and much younger stages than we have as yet been able to study. If the amnion is formed by an invagination of the layer of the embryonic vesicle, as I have previously asserted,[6] then the explanation of a number of the vesicular forms is very easy. But the recent publication of a very young normal embryo by Peters speaks against this. Yet the persistence of an epithelial layer over the vesicle in the vesicular forms, as well as its invagination, indicates that in the specimen I previously described the ectoderm must have broken out of its natural boundaries from a stage like Peters', or that this ectodermal plate upon the umbilical vesicle represents a stage before the formation of the amnion. Either explanation is plausible, but the first appears to me to be the more likely, for recently Selenka has described an ovum of Hylobates concolors in which the amnion almost communicates with the exterior of the ovum.[7] The ovum Selenka describes is about 1 cm. in diameter with an umbilical vesicle measuring 1 mm.

From all appearances the epithelial covering of the chorion of early human ova is formed long before the amnion and embryo are outlined. Judging by the early stages of other mammals, the epithelial covering of the chorion in man must be produced as Rauber's layer is formed in them. While the ovum is still wandering down the uterine tube, its epithelial covering, or Rauber's layer, is undoubtedly still smooth, and only grows into villi when the cavity of the uterus is reached. Then the syncytial layer is formed, and as evidence accumulates it becomes more and more probable that it is embryonic in origin. I have in my collection a young normal ovum from a tubal pregnancy in which the syncytial layer is very extensive, and is growing against a blood clot on one side and against normal tubal epithelium on the other. At certain points its syncytial layer has destroyed the lining epithelial cells of the tube and is in direct contact with the subepithelial tissue. The growth of the syncytial layer could be interpreted as growing from the epithelial cells of the tube to the chorion and from it to the blood clot and the lining cells of the tube on the opposite side of the ovum; but why this roundabout and improbable way of explanation when the direct is so much easier? Moreover, the characteristics of the syncytial layer are so decidedly "embryonic" that it is not difficult to separate it from tubal epithelium when the two come in contact. Even the nests of partly destroyed tubal cells are very unlike the cells of the syncytial layers.

The quantity of syncytium may be either increased or diminished. In the former instance the buds of syncytium arise from all portions of the villi as well as from the chorion proper. When there are numerous buds arising directly from the chorion the epithelial cells often become piled up until the layer is considerably more than two cells deep. The double layer of syncytial cells is also present on the inside of the amnion in a specimen (CXLII.) in which the syncytial cells "ate" through the membranes to the embryo.

The force of the growth of the syncytium may be terrific. It destroys whatever comes in front of it. It grows best when it comes in contact with mother's blood, as a study of numerous specimens shows. Its reaction upon other cells is also terrific, for whenever leucocytes come in contact with the syncytium their nuclei fragment, and they disintegrate. When the syncytium forms great masses of cells, so great that its nutrition becomes impaired, the centres of the masses become necrotic. We have here, again, all of the reactions of a parasite battling for its existence. When the growth of the ovum is retarded by the destruction of the embryo, excessive inflammation of the uterus, or other causes, the syncytium may attack the tissues of the chorion and destroy it in part. This kind of attack is favored most by leucocytic infiltration of the mesoderm of the chorion, as well as by fibrous degeneration of its walls. Yet such an attack is rare, for it appears as if the simple mesoderm of the chorion belongs to the most resistant of tissues. Under certain circumstances it can continue to grow almost by itself, for a long time resisting syncytium, leucocytes, and bacteria.

The embryologists of the early part of this century described within the cœlom of the ovum a delicate network of fibrils, the nature of which is not definitely known. This structure, the magma reticulare, is fairly well marked in normal ova and finally disappears when the amnion reaches the chorion. This is its story under normal conditions. When, however, the amnion fails to reach the chorion in due time the magma reticulare may become fluid, or in other instances it is converted into a granular mass, or magma granulare. On the other hand, the magma reticulare may be greatly increased in pathological ova of about the fourth week, with or without a diseased chorion. When this condition continues the magma reticulare may become only partly granular, as a number of my specimens show.

At the first appearance one is inclined to consider the magma reticulare as being composed of fibrin. In order to test this question, I collected a number of fresh specimens, both normal and pathological, hardened them in alcohol and then stained them by means of Weigert's fibrin stain. In no instance did the fibrils of the magma hold the stain. These tests, then, are only negative, giving us no insight as to the nature of the fibrils of the magma.

Not only is the amount of magma found in the cœlom excessive, but it may also extend through the amnion and reach the embryo. In other instances, when the embryo remains normal until the sixth week, a magma reticulare may form primarily in the amniotic cavity and ultimately become granular. Whether or not the reticular magma undergoes disintegration to form the granular remains to be shown. It is, however, noteworthy that usually either one or the other exists, but intermediate stages with both present are not rare.

In nearly all instances there are scattered throughout the magma numerous cells with relatively small nuclei and a considerable quantity of protoplasm, showing all the characteristics of the blood corpuscles of the embryo. These are the migrating cells of His. In all pathological specimens it is found that the migrating cells penetrate all of the tissues of the embryo; in fact, all of the tissues and spaces within the chorion. My specimens show all of the intermediate stages between blood-vessels filled with blood, with few migrating cells in the tissues, to empty blood-vessels with the tissues stuffed with migrating cells. These stages, together with the common morphological appearances of the blood corpuscles and the migrating cells, force the conclusion that the latter are blood corpuscles within the tissues.

It appears as if the blood corpuscles of the embryo have great power to migrate within the blood spaces before the heart is formed. In pathological embryos, when the circulation is retarded or arrested, the corpuscles leave the blood-vessels to form conditions which may be termed inflammation of the embryo. As the blood cells leave the blood-vessels to wander through the tissues, the blood-vessels continue to grow in diameter as well as in extent, for I have numerous specimens in which the aorta is distended and empty, while in other instances capillary vessels without blood within them, have grown into the villi of the chorion.

ARRESTED DEVELOPMENT OF THE EMBRYO WITH CONTINUED GROWTH OF THE OVUM.—The specimens which come under this group vary in so many respects that it is impossible for me to consider them from any standpoint except that of their approximate ages when their development was first arrested. Before doing this, I worked through the specimens from many other standpoints—their size, their membranes, and the condition of their tissues—only with unsatisfactory results. The general shape of the embryos, and their organs, however, gave me a clew to their ages when development was arrested; and when they are considered from this standpoint the results are fairly satisfactory. Knowing the time at which the development of the embryos was arrested, the other factors—tissues of the embryo, chorion, and time of the abortion—can easily be taken into consideration. Moreover, in all instances I have repeatedly compared the pathological specimens with the normal, my cabinet being well supplied with numerous sets of serial sections of both.

There are in my collection two specimens of arrest of development at the beginning of the second week (Nos. CXV. and CXXXVI.). A glance at the table shows that one of these specimens is a two-weeks' embryo in a four-weeks' ovum; the other a four-weeks' embryo in a two-weeks' ovum. In one the development of the embryo was arrested at the beginning of the second week, but the chorion continued to grow two weeks longer before the abortion; in the other the reverse is the history.

Specimen CXXXVI. appeared to be pathological before it was cut open, but it was found filled with an increased quantity of magma, within which could be seen a nor-

TABLE I.—ARRESTED DEVELOPMENT OF THE EMBRYO.*

Number.	Dimensions of ovum.	Length of embryo.	Time between last period and abortion.	Remarks.
		TWO TO THREE WEEKS.		
CXXXVI	14 × 11 × 6 mm	5 mm	56 days	Magma reticulare increased.
CXV	30 × 27 × 22 mm	3 mm	56 days	Magma reticulare greatly increased.
		THREE TO FOUR WEEKS.		
CL	35 × 30 × 10 mm	5 mm.		
CXXII	20 × 16 × 6 mm	5 mm	65 days	Amnion has reached chorion.
CX	46 × 30 × 30 mm	8 mm	82 days	Amnion has reached chorion. Embryo very much macerated.
CXLI	40 × 30 × 20 mm	8 mm	78 days	Magma reticulare within cœlom.
XCVII	33 × 30 × 15 mm	9 mm	61 days	Magma reticulare increased.
CIV	35 × 35 × 15 mm	12 mm	35 days	Magma reticulare greatly increased.
		FOUR TO FIVE WEEKS.		
LX		8 mm.		
CXXXV	105 × 65 × 65 mm	9 mm		Amnion has reached the chorion.
CLXI	50 × 25 × 25 mm	10 mm	83 days.	
CXXXIII	32 × 32 × 32 mm	11 mm	65 days	Magma reticulare greatly increased.
LIV		11 mm.		
LXIX	70 × 40 × 20 mm	13 mm		Amnion has reached the chorion.
CXXXII	42 × 30 mm	15 mm	89 days	Amnion has reached the chorion.
		FIVE TO SIX WEEKS.		
CXXXVII	60 × 50 × 30 mm	16 mm	86 days	Cord filled with a reticular mass.
LXXXI	65 × 55 × 35 mm	20 mm	84 days.	
CXLII	50 × 40 × 30 mm	20 mm	129 days	Syncytium within cavity of amnion.
		SIX TO SEVEN WEEKS.		
XCIV	50 × 40 × 30 mm	20 mm.		
CXXVIII	50 × 43 mm	20 mm	76 days.	
		SEVEN TO NINE WEEKS.		
CLII	70 × 42 × 38 mm	31 mm	70 days.	
LXXIX	50 × 50 × 50 mm	32 mm	91 days.	
CXXIV	90 × 75 × 50 mm	35 mm	126 days.	

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* The Roman numbers given the embryos correspond with the record numbers in the cabinet of human embryos in the Anatomical Laboratory of Johns Hopkins University.

mal embryo of the fourth week. Since I had never seen a chorion too small for its embryo, I had my doubts about the accuracy of my observation until the specimen was cut into serial sections. Then, to my surprise, I found an embryo practically normal of the four-weeks' stage to correspond with the menstrual history. The chorion, however, is markedly thickened, with villi, and not in cells. Both chorion and villi contain a great number of blood-vessels which are overfilled with blood. The syncytium is very extensive, large buds arising from all parts of the villi as well as from the chorion itself. Comparing it with normal specimens, the syncytium is excessive in quantity, which may account for the good nutrition of the embryo. The large amount of embryo blood also speaks for this. The trouble in this specimen seems to lie with the mesoderm of the chorion, which prevented it from expanding sufficiently. This condition was compensated by an excessive growth of the syncytium, which gave sufficient nutrition to the embryo. The entire vascular system of the embryo, umbilical vesicle, and chorion is overdistended and the peritoneal cavity of the embryo is also filled with blood. Finally, however, the equilibrium between embryo and chorion was overthrown, resulting ultimately in the abortion. This inequality is also expressed by the excessive quantity of magma within the cœlom.

The second specimen in which there was an arrest of development at the beginning of the second week is No. cxv. Here the development of the embryo is arrested and the chorion has continued to grow. This variety of abnormality is very common, and it is fairly easy to interpret the various steps by which it is brought about. Not only are specimens of this kind easy to interpret, but we have in them the key through which we shall ultimately obtain data regarding the very earliest human embryos. If an ovum four weeks old have within it an embryo two weeks old, why may not an ovum three weeks old have within it an embryo one week old? All the specimens reported in this article speak most decidedly in favor of this hypothesis. In general, this embryo is an exaggerated two-weeks' stage with a four-weeks' amnion and chorion. The great quantity of pus encircling the chorion and cutting off its nutrition, with a consequent atrophy of the syncytium, cuts off also the nutrition of the embryo, thus gradually causing its death. The overthrow of the equilibrium between the embryo and uterus is indicated by the great quantity of magma within the cœlom as well as within the amnion. The effect of strangulation of the embryo is beautifully shown within its tissues. The form of the central nervous system is extremely simple, like that of an embryo two weeks old, but it is larger and it is solid. Peripheral nerves are not present. The heart is simple, completely filled with blood; the blood-vessels have mostly disappeared. The umbilical vesicle is relatively small and filled with a solid mass of entoderm cells. Its communication with the body is almost entirely cut off. Within the body there is neither liver nor alimentary canal left. The peritoneal cavity communicates very freely with the extra-embryonic cœlom; there is no pericardial cavity. Traces of myotomes and Wolffian bodies are still left. Throughout the embryo and the magma of the cœlom and amnion there are scattered cells with all the characteristics of embryo blood corpuscles. These are undoubtedly the migrating cells already described by His.[8] In this specimen we see the later stage of this process; and, judging by all the conditions present, its duration must have been about two weeks. His describes a similar stage, differing only in that the time between the death of the embryo and the abortion is four weeks more than in No. cxv.

The two specimens described above indicate that there has been an arrest of development of some portions of the ovum and give some hints regarding the physiology of some of the groups of tissues. In No. cxv. the primary lesion was undoubtedly the endometritis, which deprived the ovum of its proper nutrition. The second portion of Table I. gives better data regarding the primary lesion as well as the probable duration of the secondary changes within the embryo.

Judging by the general appearance of specimen No. xcvii., it might be considered normal with the exception of the excessive magma reticulare. Sections show, however, that the chorion is fibrous and the embryo is infiltrated with migrating cells which have also invaded the entire cœlom. The age of this specimen, if determined by the embryo and its organs, is not over twenty-eight days, while the menstrual history calls for at least thirty-one days. We have, therefore, to do in this specimen with an embryo which has undergone pathological changes for at least three days. The chorion is fibrous, and I am inclined to locate the primary trouble in it. The chorion is the least changeable of all the embryonic tissues, and, therefore, it may follow that a slight alteration in it produces grave consequences. The early changes in the process of degeneration of an embryo are beautifully shown in this specimen. The central nervous system is greatly dilated, the boundaries of the abdominal viscera are obscured, and the vascular system is greatly dilated. The entire embryo is filled with migrating cells which show all the characteristics of embryo blood corpuscles.

A stage slightly in advance of the above is shown in specimen No. civ. Here, however, the membranes appear normal, but the walls of the umbilical vesicle are fibrous, the magma is greatly increased and granular, and the embryo is macerated and straightened. The changes within the embryo are much more in advance than in xcvii., the liver tissue being entirely obscured. The vascular system is undoubtedly blocked, and the migrating cells have invaded all of the tissues, including the umbilical cord, to the chorion.

In both of the above specimens the embryos must have been strangulated sufficiently to cause their death, thus permitting the blood corpuscles to leave the vascular system to invade the tissues and the cœlom. In specimen cxxii. the primary lesions were not so severe, the embryo continued to grow but not develop, and the amnion continued to dilate until it met the chorion. The primary trouble here again appears to be a fibrous change in the chorion. The central nervous system is distended, the vascular system is dilated, and the aorta is empty. The tissues of the embryo are partly filled with migrating cells. Specimens cx. and cxli. show the same process two or three weeks later. The specimens came from the same woman, who was suffering from leucorrhœa, and in general show the same characteristics. They are both embryos four weeks old which had been retained in the uterus another four weeks after strangulation.

In Nos. cx. and cxli. the villi of the chorion are almost destroyed, and the chorionic walls are converted into a fleshy mass invaded by leucocytes. The embryos are atrophied, the organs are obliterated, and the vascular systems are distended. That the process was slow is indicated by the amnion having reached the chorion and the general form of the embryo and its tissues corresponding with that of cxxii. The uterine trouble of the mother, the extreme changes of the chorion in both specimens with almost identical changes in both embryos, prove, as much as these specimens can prove, that there was a gradual stangulation of the embryo due to inflammation of the uterine mucous membrane, first affecting and then destroying the villi of the chorion.

The specimens in my collection of embryos of the fifth week lack the data of those of the fourth week, yet something can be made out of them. Undoubtedly the youngest of this group is No. cxxxiii. The villi of the chorion appear normal but have little syncytium at their tips. Between the villi, upon the chorionic walls, there is an excessive quantity of syncytium. The cœlom is completely filled with an excessive quantity of magma, in which lies the embryo greatly cramped and closely enveloped by the amnion. Terrific changes have taken place within the embryo. In every respect this embryo is like No. xcvii., only it is a few days older. The migrating cells have invaded the entire embryo and at numerous points they were leaving the body to enter the cavity of the amnion. At these points the epithelium of the embryo is exfoliated. Specimen CLXI., whose abortion was caused by repeated attempts on the part of the mother, aids materially in locating the beginning of the pathological changes in the ovum. While there is great activity in the leucocytes and syncytium on the outside of the chorion, there is more activity of the migrating cells within the embryo, and this latter condition must be viewed as being secondary.

The other embryos of the fifth week indicate that a slower process has taken place in them. The history of one of them, and the dimensions of the chorion of others, also speak for this. The least changed of all the specimens is No. CXXXII. The history of the specimen as well as the dimensions of the chorion indicate that this specimen must have been alive but did not grow to any marked extent during three weeks preceding the abortion. The organs of the embryo are about normal in form and structure, with a small number of migrating cells in the tissues and peritoneal cavity. Specimens LX. and LIV. show slight tissue changes in advance of CXXXII. More marked changes occur in LXIX., which, judging by the size of the chorion, must have been undergoing pathological changes for a number of months before the abortion. In No. LXXXII. the villi of the chorion are considerably atrophied, while in LXIX. they are entirely wanting, with fibrous chorionic walls. The embryo itself is atrophic and much macerated. The central nervous system is distended, the sharp contour of the organs is lost, and the vascular system is distended. Migrating cells have invaded all the tissues, including the peripheral nerve bundles and the umbilical cord.

While most extreme changes will take place in several weeks in pathological embryos of the fourth week, in embryos of the fifth week months are required to produce corresponding changes. In specimen LXIX. the slow process must have been at work for months, producing all sorts of tissue abnormalities, from multiple papilliform growths of the entire epithelial covering of the body to an atrophied head. In specimen CXXXV. this process of tissue change and organ destruction is still more advanced. The primary lesion of this specimen must also have been in the chorion. The villi are all destroyed while the chorion remains as a thin fibrous membrane infiltrated with leucocytes and a few nests of syncytial cells. The entire chorion is very large, lined by an amnion, and is filled with a jelly-like substance which hardened to the consistence of glycerin-jelly in formalin. The atrophic embryo shows the usual nervous system with the head end of it completely destroyed. The outline of the organs and peritoneal cavity is also very indefinite, the entire embryo being filled with migrating cells. The vascular system is more definite than are other portions of the embryo, it no doubt having functioned longest. The head end of the embryo has become greatly atrophied, its front end being converted into a mucoid mass. The eyes have sunken deep into the head but the lenses continued to develop into hard pearls composed of lens fibres. The front end of the chorda is expanded into a large mucoid tumor on either side of which there is a large cartilaginous tumor. All this shows that development ceased long before the ovum was aborted, but that tissues already established continued to grow and to degenerate into all sorts of masses.

In addition to the groups of embryos of the third, fourth, and fifth weeks, there are several specimens of later date which show that the changes in form and structure are not likely to occur when there is an arrest of development in later stages. Specimen LXXXI. seems to have its primary trouble in the chorion, it being fibrous and invaded by leucocytes as well as syncytium. The amniotic cavity is greatly distended and the embryo is macerated with an ulcerated crest on top of its head. The whole specimen suggests death and destruction of tissues without any indication of further growth of any of the parts.

Specimen CXLII. also shows the great resistance of an older embryo that has been dead for several months before the abortion. The syncytium has also been active, having eaten into the walls of the chorion and its villi and having entered the cavity of the amnion. Here these cells form their characteristic double layers again and also invade the tissues of the thickened amnion.

Embryo CXXVIII. is a perfect normal specimen with a normal chorion of about the sixth week, but the history shows that it must be older. The peculiarity of this specimen is the delicate reticulum of fibrils over the embryo within the amnion. It may be that this is the beginning of the granular magma frequently found with the amnion of older pathological ova. Of this same date I have another embryo, XCIV., with fibrous degeneration, as well as some leucocytic infiltration of the chorion. The embryo is normal in form and the amnion is packed with a mass of granular magma. There are many indications of destruction of the tissues of the embryo, but none of growth and regeneration.

No. LXXIX. is similar to XCIV. but older. It also has leucocytic (also syncytial) invasion of the chorion, necrosis of the tissues of the embryos and so on. The epithelial covering of the embryo has partly fallen off, but at the border line of the exfoliation there appears to be an attempt at regeneration. Its lines are not ragged, but the regenerating border is elevated and rounded. There are no cell figures. No. CLII., much like LXXIX., shows a more advanced stage of degeneration. In this specimen the cause of the strangulation of the embryo is to be found in the endometritis, which gradually cut off the nutrition of the chorion, and later aided in destroying the villi.

Among these specimens I may mention here a remarkable one, CXXIV., in which the nutrition must have been impaired some time during the second month of pregnancy. The entire duration of this pregnancy must have been at least four months. The large chorion has on one side of it a small placenta which is infiltrated with leucocytes. The quantity of syncytium is normal but appears necrotic, a change which may have taken place immediately before the abortion. Between the chorion and amnion there is a large cœlom. The walls of the amnion are greatly thickened. The umbilical cord is thin and greatly twisted. The general form of the embryo is nearly normal, but there are club hands and club feet. The external ear is also rudimentary and pointed. If this specimen is compared with a normal embryo of the fourth month it is seen at once how much too small and how distorted this embryo is. In this instance it is interesting to note that accompanying this abnormal embryo there is a diseased placenta, a distended extra-embryonic cœlom, and a very thin umbilical cord.

Embryos with Slight Abnormality.—In addition to embryos CXXVIII. and XCIV. described above, I have several specimens in my collection with slight abnormalities which could not greatly affect the further growth and nutrition of the embryo. No. VI. is undoubtedly a normale embryo, as it was obtained by inducing abortion seventy-seven days after the beginning of the last menstrual period. Its tissues all appear normal with the exception of a small vesicle on the ventral side of the lower tip of the spinal cord. This vesicle is lined with one layer of cylindrical cells; other embryos of the same stage, in my collection, do not possess it. A pathological embryo of about the same age, No. LXXXI., has a similar dilatation at the lower tip of the spinal cord.

There are in my collection three specimens of hernia of the liver (X., XCIV., XXX.). Embryo in X. is stumpy and poorly shaped, but the tissues appear normal. No. XCIV. is abnormal while XXX. is normal.

DEGENERATION OF THE EMBRYO, LEAVING ONLY THE UMBILICAL CORD.—This remarkable group of specimens caused me a great deal of trouble, and not until studying them again and again could I make anything of them. With but one exception (LXXVII.) they were all found in ova which otherwise appeared normal. The main data are given in Table II.:

TABLE II.

No.	Diameter of ovum.	Dimensions of embryonic mass.	Time between last period and abortion.
	mm.	mm.	days.
XXXVII	25 × 18 × 15	2 × 2	
CXXX	15 × 10 × 6	7 × 2	14
XXXII	30	9 × 2	82
XXV	25	6 × 2	
LXXVII	70 × 40 × 30	1 × 0.25	

In general, the size of the cord does not correspond to the size of the ovum or to its age when determined from the last menstrual period. In specimens XXXII. and CXXX. the embryonic masses are much alike, and they might well represent the cords of embryos of the second month. The size of the ovum in XXXII. calls for this age, but the time between the first lapsed menstrual period and the abortion is much greater. In specimen CXXX. the size of the ovum, as well as its history, places it in the early part of the third week, but at this time the cord and umbilical vesicle are much less developed than in this specimen.

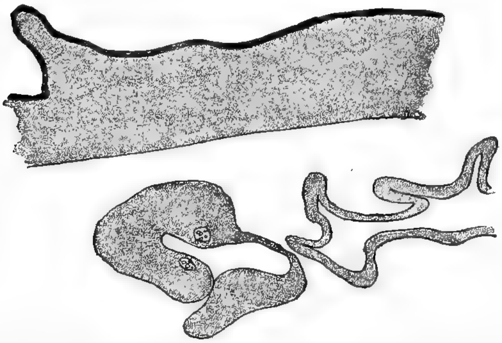
FIG. 1861.—Section through the Head, Umbilical Vesicle, and Chorion of Specimen No. XXXVII. The pharynx and first aortic arches are cut across in the head. × 10 times.

It appears to me that we have in the five specimens given in Table II. five stages of a variety of pathological embryos intermediate between ova without any embryos at all and those forming embryos which are greatly deformed. At an early stage, after the formation of the amnion, through unknown causes, the embryos die, or, having been originally deformed, cease to grow, while the amnion, cord, and chorion grow on as if nothing had happened. Therefore the normal villi of the chorion and the comparative absence of magma reticulare. This continues, however, until the circulation through the embryo is greatly needed to keep up the equilibrium between the ovum and uterus and the abortion follows.

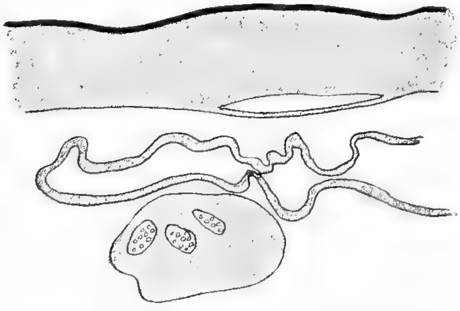
FIG. 1862.—Section through the Umbilical Cord and Vesicle and the Chorion of No. XXXVII. × 10 times.

The earliest stage of this form of degeneration is represented in specimen XXXVII. (Figs. 1861 to 1863), which is made up of a very atrophic head of an embryo seated upon the tip of the umbilical cord within the amnion

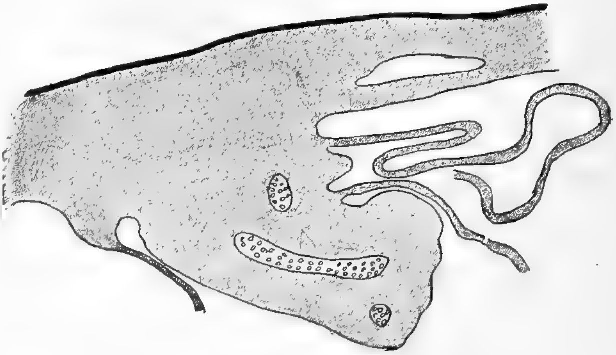
FIG. 1863.—Section through the Attachment of the Umbilical Cord and Vesicle to the Chorion in No. XXXVII. × 10 times.

The umbilical vesicle is attached to the side of the cord but does not extend in any way to the embryo. The very rudimentary nervous system, the absence of the heart, as well as other causes, are sufficient to overthrow the further growth of this embryo had the abortion not occurred.

The next stage is represented in specimen CXXX. (Figs. 1864–1866). Here the embryo is already reduced to a mass of cells which no longer contains nervous system or vascular system. It naturally dies in consequence of the absence of these important members and thus interferes with the equilibrium of the ovum. The cord is filled with blood-vessels and blood, showing again that an embryo must have been present at an earlier date.

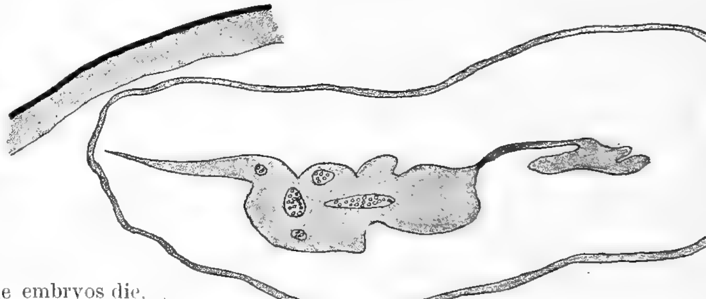
FIG. 1864. Section through the Amnion, Cord, and Remnant of the Embryo of No. CXXX. × 10 times.

Had the amnion not been complete, the remnants of the embryo would probably have fallen off, converting this specimen into one represented in the next stage.

The relation of the amnion to the cord makes it probable that this specimen is not over three weeks old. The large cœlom also speaks for this. The large and detached umbilical vesicle is difficult to account for. It may be that the early destruction of the embryo and the overthrow of the circulation through the umbilical vesicle may have hastened its growth and favored its separation from the umbilical cord. Of course it is possible that the lasting connection between the vesicle and umbilical cord was separated by traumatic means, but a tear is not visible at any point.

A stage slightly more advanced is represented in specimen XXXII. (Figs. 1867 and 1868). Here the amnion fills the ovum completely, the embryo is entirely destroyed, and the cord shows a number of secondary changes. It may be that this stage is really but little in advance of the specimen cxxx., as in it the embryo remnants were well protected by the amnion. In both specimens, however, the blood-vessels are well filled with blood, and at points the vascular walls are broken and the cells infiltrate the surrounding tissues. These pictures are extremely striking and suggest an attempt at repair by the process of inflammation at this early stage. The tip of the cord is intensely stained by the carmine, suggesting very much a section through an ulcerating wound. The nucleated blood cells are out among the mesoderm cells of the cord and become necrotic as they approach its ragged edge.

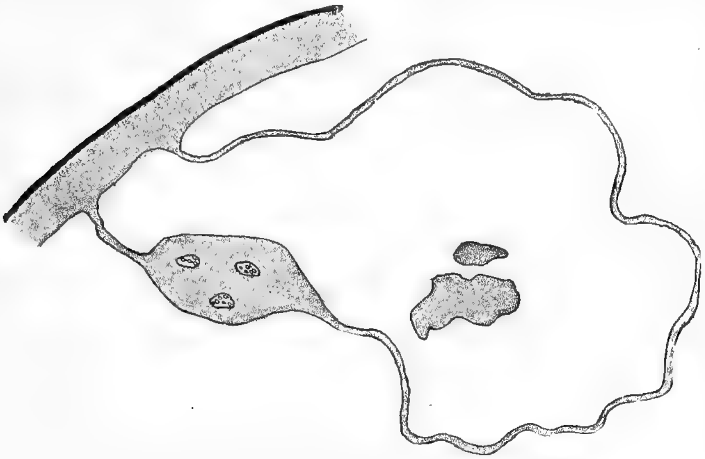
FIG. 1865. Section through the Amnion, Cord, and Chorion of No. CXXX. × 10 times.

The stage as represented in specimen xxxii. is shown in a somewhat advanced form in specimen xxv., Fig. 1869. The stump end of the cord is not so ragged as before; it has become rounded and the larger blood-vessels are not overdistended with blood. It appears as if the stage of great reaction between the blood cells and the necrotic tissue had passed and the wound had nearly healed.

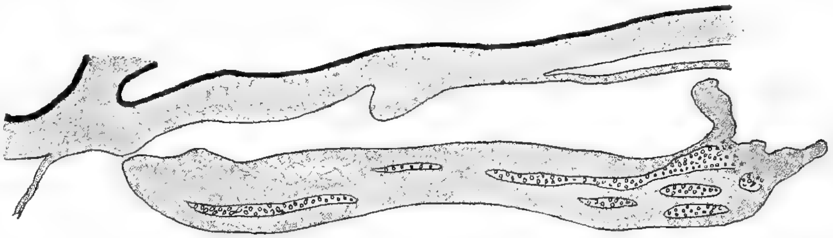
FIG. 1867.—Section through the Cord and the Amnion at its Attachment to the Chorion of No. XXXII. × 10 times.

In the five specimens described above, the morphological characteristics of the chorion, villi, and syncytium appear normal. The magma reticulare, however, is greatly diminished in quantity or is entirely wanting. With the exception of the partly deformed embryo, then, there was little to suggest that the specimens are pathological. It appears that the destruction of the embryo with a deficient quantity of magma reticulare is the only sign to account for the abortion. Specimen lxxvii., however, shows that the ovum can be retained in the uterus for a long time after the embryo has been destroyed, and that under these circumstances decided secondary changes may take place. In this specimen the chorion and amnion have both become more fibrous than normal, appearing as if all the delicate mesoderm spaces had disappeared. At the point of juncture between the amnion and chorion there is a nodule which no doubt represents the last remnant of the umbilical cord. The mesodermal tissue of the villi has also become fibrous, and there are no blood-vessels within them. There is no magma. While this stage has been reached on the inside of the ovum, the syncytium and leucocytes on the outside have become most active. With every increased quantity of fresh blood between the villi the syncytium receives new food and continues to grow. Wherever syncytium comes in contact with leucocytes it causes their destruction, as the fragmentation of their nuclei shows. But this cannot continue forever, and finally the syncytium, as well as the leucocytes, attacks the mesoderm of the chorion and its villi, and in specimen lxvii. all stages of this process are shown. Similar pictures are seen in specimen xciii., which in all probability also belongs to this group of abnormal ova. In cxlii. the syncytial attack is still more intense; it invades the mesoderm of the chorion and its villi, has entered the cavities of the cœlom and amnion, and is attacking the amnion.

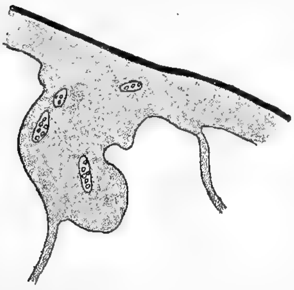
FIG. 1866.—Section through the Attachment of the Amnion and Cord to the Chorion of No. CXXX. × 10 times.

The excessive growth of syncytium and its invasion of the maternal tissues, ultimately forming malignant tumors, was first pointed out by Sänger,[9] and has since been confirmed numerous times by competent investigators. Recently, however, Neumann[10] has shown that not only does the syncytium enter the tissues, and ultimately the circulation of the mother, but it also invades the tissues of the chorion and its villi. This observation I can confirm, but am unable to contribute to its diagnostic value. In general, it appears to me that destruction of the chorion and its villi may be accomplished by the syncytium, but this is exceptional. It appears that when the chorion is attacked by the syncytium there are usually great quantities of leucocytes accompanying it, and this condition may also favor the formation of deciduomata. At any rate the fact is established that the syncytium may enter and destroy the chorion and its villi in uterine moles of long standing.

OVA NORMAL IN FORM WITHOUT EMBRYOS AND UTERINE MOLES.—The ten specimens which come under this head differ very much from one another in form and age, but careful consideration of all their structures shows that they belong together. They are all alike in that the embryos are missing, and they must have been destroyed at a very early date; in seven of them this must have taken place before the embryo was six weeks old, as there is no trace of an amnion left; while in three of them (xciii. and lxxvii.) the amnion is fully formed, but the general appearance of the ova shows that they represent early stages in development.

Table III. gives the general characteristics of the ova which represent all stages of uterine moles. The youngest specimen, lxxi., is an ovum about two weeks old, normal in every respect, with the exception that the embryo is wanting entirely. Within the cœlom, however, there is a small nodule about 1 mm. in diameter, which may represent the remnant of the embryonic mass. It is

TABLE III.—TABLE OF OVA WITHOUT EMBRYOS AND UTERINE MOLES.

Number.	Diameter of chorionic mass.	Diameter of cœlom.	Time between last period and abortion.	Amnion.	Chorion.	Villi.	Syncytium.	Magma.
LXXI	10 × 9 × 5 mm.	8 mm.	40 days	None.	Normal.	Normal	Normal.	Normal.
XX	20 × 14 × 6 mm.	16 mm.		None.	Normal.	Normal	Normal.	Increased.
XXIX	30 mm.	24 mm.		None.	Fibrous.	Atrophic.	Excessive.	Excessive.
LV	35 × 20 × 14 mm.	15 mm.	54 days	None.	Leucocytic invasion	Necrotic.	Necrotic.	Granular.
CLIII	50 × 20 × 20 mm.		77 days	None.	Leucocytic invasion	Normal	Normal.	None.
LXX	45 × 30 × 28 mm.	5 mm.	113 days	None.	Necrotic.	Hypertrophic.	Excessive.	None.
LXXXII.	75 × 60 × 40 mm.		279 days	None.	Hypertrophic.	Atrophic	Diminutive	None.
XCIII	40 × 20 mm.	7 mm.		Present.	Syncytial invasion.	Hypertrophic	Excessive.	None.
CLIX	Walnut		70 days (?).	Present.	Syncytial and leucocytic invasion.	Syncytial and leucocytic invasion.	Excessive.	None.
LXXVII.	70 × 40 × 30 mm.	20 mm.		Present.	Syncytial and leucocytic invasion.	Syncytial and leucocytic invasion.	Excessive.	None.

composed of twisted discs looking much like the dried blood corpuscles of the frog, being pigmented, but they would not stain. If this mass represents the remnants of the embryo, it must have died long before the abortion took place. Embryo XX. also appears normal with the magma normal or slightly increased in quantity and lumpy. These small nodules of magma appeared to the naked eye like remnants of the embryo, but sections of the ovum easily demonstrated the contrary.

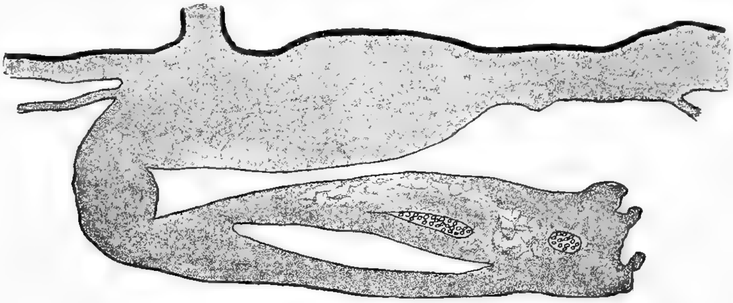
FIG. 1868.—Section through the Attachment of the Umbilical Cord to the Chorion in No. XXXII. × 10 times.

The specimens LXXI. and XX. would be considered normal if they had within them a normal embryo. It appears that to the extent, as represented in these specimens, the chorion develops independently of an embryo, but its further growth is affected if no embryo is present. It may be noted that in the ovum of the second week the nutrition must reach the embryo through the fluid of the cœlom and thence through the umbilical vesicle. Toward the end of the second week the blood-vessels of the embryo reach the chorion,[11] and at this time nutrition must reach the embryo through its blood-vessels, which now reach to the villi of the chorion. So if an early embryo is missing we should find marked changes in the chorion after the beginning of the third week. This proves to be the case in specimen XXIX. The walls of the chorion and its villi are fibrous and thickened. The syncytium is very extensive; its borders are no longer sharply defined, and at points it invades the chorion. Many of the islands of syncytium are enclosed in a mucoid, and sometimes fibrinous, envelope. This process is still further increased in specimen LV., which from its size and history belongs to the beginning of the fifth week. The cavity of the cœlom has become smaller, the villi are matted together, and with their surrounding syncytium appear necrotic. There is much blood and fibrin between the villi and leucocytes have invaded the wall of the chorion. In this specimen we have a typical mole which is two weeks older than the specimen LXXI.

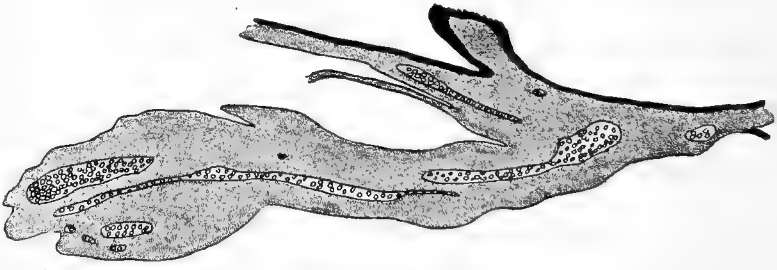
FIG. 1869.—Section through the Umbilical Cord and Amnion at their Attachment to the Chorion in No. XXV. × 10 times.

Another modification of the degenerative process is shown in specimen LXX. It is an hydatid mole. The chorion is small, collapsed, deeply buried in the specimen, and from it arise enormous villi with very large spaces within them. Between the villi there is a considerable quantity of blood which gave nutriment to the excessive syncytium.

To what extent a collapsed ovum may grow is shown in specimen LXXXII. A large solid mass the size of a duck's egg was expelled nine months after the last menstrual period. At the end which lay in the os uteri there is an extensive ulceration of the mole; otherwise it is very compact. After it had been hardened, I cut it into sections which, to my astonishment, contained a collapsed chorion sending folds in all directions throughout the specimen. Through the middle of the specimen there are large spaces along the collapsed chorion filled with fresh blood. The opposite walls of the chorion are in apposition throughout most of the specimen, and at points they have grown together. There is no amnion, and on this account I place the beginning of this mole back to the first month of pregnancy. The extensive ramification of the folds of the chorion shows that it must have continued to grow throughout the nine months of its existence, this being made possible by the nutrition brought to it by the fresh blood in its interior. Islands of syncytial cells are located throughout the specimen upon the chorionic wall. This syncytium shows active growth and its cells stain well at numerous points where it comes in contact with fresh blood. All the syncytial masses which are distant from the fresh blood are necrotic, which is undoubtedly due to the lack of nutrition. Nests of leucocytes with fragmented nuclei are scattered throughout the specimen. The walls of the chorion are not invaded by the syncytium.

The above group of specimens shows all stages of mole formation before the amnion is in contact with the chorion. There are, however, three other specimens, CIII., LXXVII., and CLIX., in which the chorion is lined with an amnion. These must have arisen from specimens like those in which the embryo was destroyed, leaving only the umbilical cord. Specimen LXXVII. I have already discussed with that group in which the embryo is destroyed, leaving only the cord (Table II.), and to it I now add XCIII. in discussing it with this group.

In specimen LXXVII. there is a small stump of the umbilical cord left, while the chorion has a large quantity of blood and syncytium between its villi. At points the chorion and villi are invaded by the syncytium. In XCIII. this process of destruction has increased, the chorion is thickened and irregular, and it is surrounded by hypertrophied villi with great quantities of blood and syncytium between them. Over the entire mass there is a layer of syncytium covered with blood and fibrin, then a space, and then the decidua. Within the mesodermal tissue of the chorion there are occasional islands of syncytium.

The two groups of pathological ova, given in Tables II. and III., are undoubtedly caused by an arrest of development and a destruction of the embryo before the fifth week of pregnancy. In one of the groups this took place very early before the amnion had been fully formed and I am strongly inclined to believe that they represent specimens in which the amnion did not form at all —the so-called vesicular forms. In the second group the embryo and amnion were formed, then the embryo was destroyed, leaving the amnion and chorion. In both sets the equilibrium by which the normal growth of the chorion is favored was overthrown, due to the destruction of the embryo. In case the ovum is not aborted, it continues to grow in an irregular fashion, and the chorion or villi either become atrophic or hypertrophic. The syncytium in all cases continues to grow as long as it receives the proper nutrition, and in certain instances it attempts to destroy the chorion and its villi.

VESICULAR FORMS OF PATHOLOGICAL EMBRYOS.—The different varieties of pathological embryos described above can all be explained as forms of arrested development of the embryo, its partial destruction or its complete destruction. In all instances the chorion proves to be the most resistant tissue and continues to grow after forming a large cyst-like ovum, but occasionally collapsing to form a fleshy mole. When the primary trouble is in the embryo, usually the chorion appears normal; but when the primary trouble is in the chorion the embryo is immediately affected, often resulting in its strangulation. In the younger strangulated embryos the tissue reactions are very marked, while in the older strangulated specimens there is a slow and irregular growth, but not development of the organs.

In addition to the atrophic embryos and moles there is a group of vesicular forms which are extremely difficult to understand. It has frequently been asserted that this group represents early pathological embryos, but as yet no positive proof has been brought forward to substantiate this view. All the specimens at my disposal indicate that the vesicle is the umbilical, for in it there is found the characteristic mesoderm with blood-vessels filled with blood. This is naturally what we would expect to find, as the blood-vessels arise in the umbilical vesicle and grow into the embryo. In the very early normal human embryo, described recently by Peters, we have a very small amnion completely closed with the head end of the amnion not wholly covered with mesoderm. There can be no question about this specimen being normal. I think, on this account, that the young specimen (No. XI.) described by me several years ago must now be considered pathological. Yet this does not indicate that the amnion never communicated with the cœlom. None of the facts are against this hypothesis, and many of the pathological specimens in my collection speak for it. At any rate, the walls of the vesicular forms are not only formed of a layer of mesoderm, in which are embedded blood-vessels and lined with a layer of entoderm cells, but are covered with a layer of epithelium which in a number of specimens form an invagination—the amnion. This outer covering of the vesicle, which I shall term the ectoderm, may represent an early normal form of the ectoderm or it may represent a displaced ectoderm in a stage as early or earlier than the Peters specimen.

The ectodermal covering of the vesicle is usually present in the vesicular forms and nearly always absent from the umbilical vesicle in the normal embryo. In a large collection of serial sections of normal embryos I have found it present but once. These facts can be interpreted in either of the ways given above and need not, therefore, be discussed further. At any rate, the epithelial layer covering the vesicle in the pathological ova is nearly always present, and in my description of them I shall assume that it is the ectoderm.

The fact that there is so great a morphological difference between the vesicular embryos and the older pathological embryos makes it likely that some very marked barrier lies between the two varieties. This undoubtedly is the amnion, for in the one it is absent or not closed, and in the other it is present. In order to bring the vesicular forms into any sort of harmony it is necessary to assume that the ectodermal covering of the vesicle is either a displaced amnion or that it is an arrested development of an extremely early normal stage.

That the cavity of the amnion may have communicated at an early stage of its development with the cœlom is indicated by Giacomini in his thirteenth communication.[12] The pathological embryo in the specimen he describes is not entirely encircled by the amnion, for the head of the embryo protrudes through an opening into the cœlom. A similar, but normal specimen, is described by Siegenbeek Van Heukelom.[13] This specimen dates from the end of the second week. The amnion is not complete. In two successive sections the amnion has in it an opening in the dorsal median line which Van Heukelom believes to be artificial, for free chromatin granules are present in the tissues in the immediate neighborhood of the opening. A similar condition is present in the Peters embryo, as the amnion is not entirely enclosed with a layer of mesoderm but protrudes into the cœlom.

The first vesicular specimen of my collection which I

TABLE IV.—VESICULAR FORMS OF PATHOLOGICAL EMBRYOS.

Number.	Dimensions of ovum.	Dimensions of vesicle.	Time between last period and abortion.	
XIII	8 × 7 mm	1.0 × 6 × 6 mm		Amnion formed.
CXXXIV	17 × 11 mm	9.0 × 3 mm	33 days	Amnion partly formed.
XI	10 × 7 mm	1.5 × 1 mm	41 days	Amnion partly formed.
LXXXVII	24 × 16 × 9 mm	2.5 mm	42 days	Partial amnion.
LVIII	20 × 18 × 12 mm	6.0 mm	71 days	Partial amnion.
LXXVIII	36 × 33 × 13 mm	1.0 × 6 mm	87 days	Multiple amnion.
XXIV	21 × 16 × 5 mm	2.6 mm		Multiple amnion.
XIV	30 mm	1.5 mm		No amnion.
CXXXIII	17 × 14 mm	2.0 × 1.5 mm	27 days	No amnion.
XXI	40 × 30 mm	5.5 × 3.5 mm		No amnion.
CXXX	15 × 10 × 6 mm	4.0 × 3 × 1.5 mm	14 days	No amnion.
CXLVII	30 × 27 × 20 mm	1.0 mm		No amnion.
CXLIII		25.0 × 10 mm		

shall describe is No. XIII. It is a double vesicle, amnion, and umbilical vesicle attached to the chorion. The cœlom is filled with a considerable quantity of magma reticulare. The walls of the vesicles are fibrous and thickened, and between them there is a thickened mesoderm. The tissues of the vesicles and their cavities are filled with a considerable number of migrating cells. Figs. 1870–1872 show all the layers of the embryonic mass in their normal position with two large blood-vessels embedded in the mesoderm. In the embryonic stalk the blood-vessels unite into a single trunk. There is no heart. The stage of this specimen is midway between Graf Spee's v. H. and Gle., and a little earlier than the embryo Eternod[14] has described recently. This specimen shows also that the blood-vessels filled with blood may grow to the chorion before the heart has even existed. This fact is not remarkable when considered in connection with our knowledge of the growth of the blood-vessels from the umbilical vesicle to the body of the embryo to form the heart. Furthermore, Loeb[15] has shown recently that when the heart of embryo fishes is poisoned with KCl a complete set of blood-vessels is developed without any circulation whatever. The fact that blood-vessels may grow into the villi of the chorion without the presence of circulation or blood corpuscles and the great power the blood corpuscles possess to wander through any of the tissues of the embryo, exclude to a great extent the mechanical idea of the first formation of the blood-vessels.

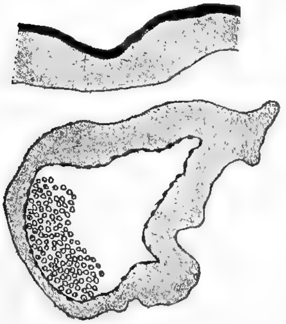

FIG. 1870. — Section through the Umbilical Vesicle and Chorion of Specimen No. XIII., His' No. XLIV. Blood corpuscles are within the cavity of the vesicle. × 30 times.

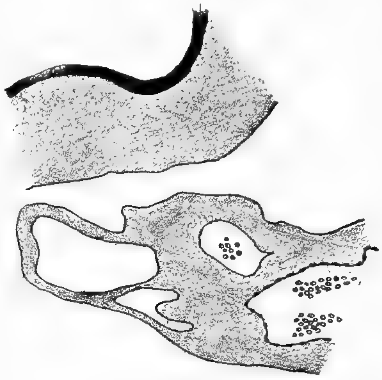

FIG. 1871.—Section through the Amnion, Jugular Veins, Umbilical Vesicle, and Chorion of XIII. × 30 times.

The beginning of the arrest of development in specimen XIII. must have taken place after the amnion was completely formed. Had it continued to grow it might have produced an embryo like CXV. described above. An earlier stage could hardly have done this, so we find in No. XIII. an intermediate stage between the nodular and atrophic abnormal embryos.

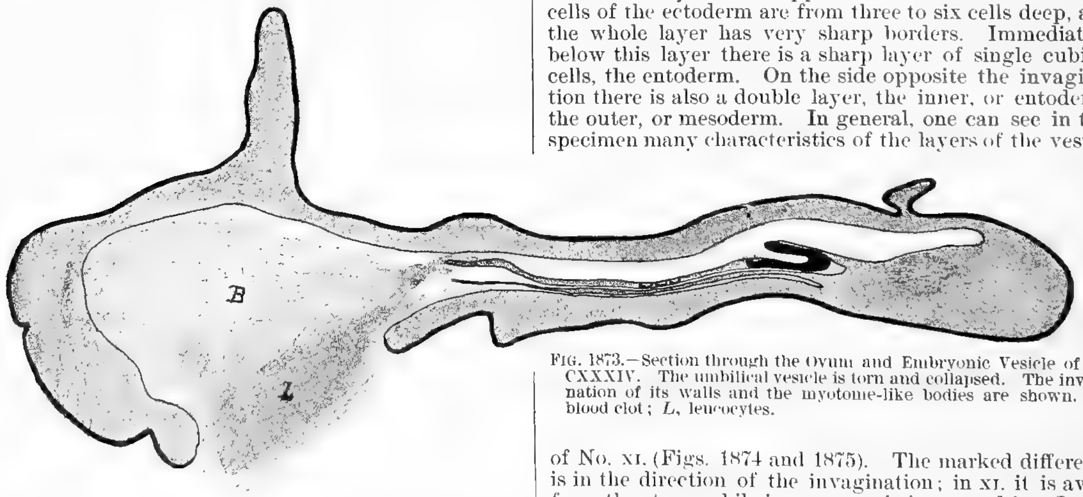

FIG. 1873.—Section through the Ovum and Embryonic Vesicle of No. CXXXIV. The umbilical vesicle is torn and collapsed. The invagination of its walls and the myotome-like bodies are shown. *B*, blood clot; *L*, leucocytes.

One of the most remarkable specimens which may be discussed in this connection is No. CXXXIV. From external appearances the ovum cannot be over seventeen days old. A few days before the abortion took place the ovum was punctured and a clot of mother's blood formed within the cœlom. The activity of the leucocytes was terrific, for they encircled the embryo, entered its tissues, and invaded the chorion. We can fairly presume that the embryo was infected with mother's blood somewhere in the neighborhood of the twelfth day of pregnancy, and that its development was partly arrested at that time. Within the ovum there is a large vesicle which is collapsed (Fig. 1873). It is attached to the chorion by means of a firm pedicle. The blood-vessels of the embryo reach to the chorion and enter the villi immediately over the attachment of the pedicle to the chorion. In addition to the reaction between the leucocytes of the mother and the cells of the embryo the most remarkable thing is the arrangement of the germ layers.

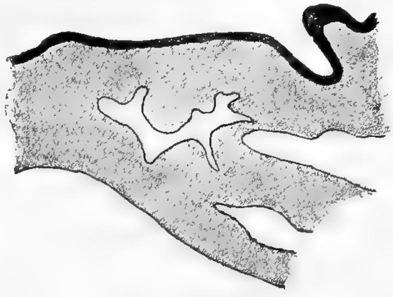

FIG. 1872.—Section through the Umbilical Vesicle as It Joins the Chorion in No. XIII. × 30 times. The large irregular space in the chorion is a blood space which communicates with the veins of the embryo.

Fig. 1873 shows in general the collapsed vesicle, composed mostly of two layers with a deep and short invagination of a layer which appears to be the ectoderm. The cells of the ectoderm are from three to six cells deep, and the whole layer has very sharp borders. Immediately below this layer there is a sharp layer of single cubical cells, the entoderm. On the side opposite the invagination there is also a double layer, the inner, or entoderm, the outer, or mesoderm. In general, one can see in this specimen many characteristics of the layers of the vesicle of No. XI. (Figs. 1874 and 1875). The marked difference is in the direction of the invagination; in XI. it is away from the stem, while in CXXXIV. it is toward it. In addition, the ectoderm lining the invagination of embryo CXXXIV., the mesoderm on the side near the blood clot, is arranged in a peculiar manner, suggesting myotomes.

There are five of them, and they are surrounded with embryo blood as well as leucocytes. The wrong direction of the invagination of the ectoderm, and its wrong relation to the "myotomes," make it extremely difficult to interpret this specimen. I am inclined to the opinion that the clot of blood arrested the development of the embryo when it was in the stage represented by No. XI., but that the parts continued to grow, shifting the layer into this abnormal position. The amnion did not close, the blood-vessels of the embryo failed to form a heart, but continued to grow in all directions through the walls of the vesicle, its stem, the chorion and some of its villi. The mesoderm continued to develop for a while and produced aborted myotomes.

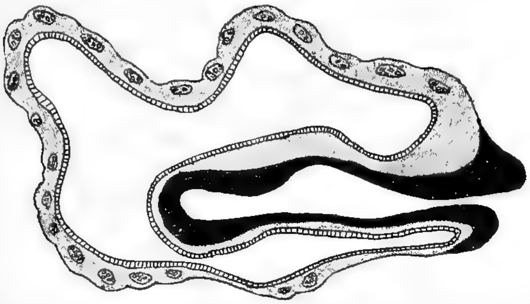
FIG. 1874.—Section through the Umbilical Vesicle and its Invagination of Specimen No. XI. × 50 times. The three layers correspond with the ectoderm, mesoderm, and entoderm. The invagination marks the cavity of the amnion.

A specimen similar to the experimental embryo CXXXIV. is No. XI. This specimen has been described in detail in the *Journal of Morphology,* vol. xii., and in the Johns Hopkins Hospital Reports, vol. ix. At that time I used this specimen as a basis upon which to construct a theory of the formation of the amnion. The general arrangement of the layers is given in Figs. 1874 and 1875. Entoderm within, mesoderm with blood-vessels in the middle, and a thick ectodermal plate on the outside. A deep invagination of all three layers is the amnion. A sharp allantois is within the stem.

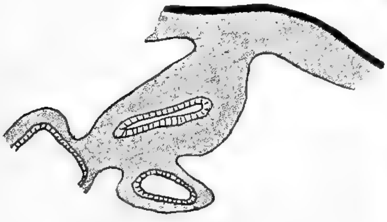
FIG. 1875.—Section through the Stem Uniting the Umbilical Vesicle with the Chorion in No. XI. × 50 times. The cavity within the stem lined with epithelium is the allantois.

Specimen LXXXVII., Figs. 1876 and 1877, corresponds with XI. as well as with CXXXIV., which is an experiment upon a normal embryo. The age of this specimen is about in the neighborhood of two and a half to three weeks, judging by a normal embryo which was within this same ovum. The large vesicle I believed at first to be the umbilical vesicle of the embryo present in the ovum, but sections of them both showed that the embryo had its own normal umbilical vesicle, while the additional vesicle showed marked alterations. Its walls are made up of three distinct layers—an outer, composed of cylindrical cells; a middle, in which are located blood islands; and an inner composed of flat cells. With the exception of its thickened walls, it appears as a normal umbilical vesicle which is inverted. The outer epithelial layer does not cover the entire vesicle. On one side there is a deep invagination of all three layers, as shown in the figures.

The presence of this vesicle, in addition to a normal embryo within the ovum, is in itself remarkable. I am inclined to interpret it as an abnormal second embryo. The invagination brings it in line with the embryos described above. Remarkable is it that the outer layer is so extensive, that the invagination is so small, and that blood islands are included in the walls of the invagination.

Closely related to LXXXVII. is specimen LVIII., Figs. 1878 and 1879. The mesoderm of the vesicle, pedicle, and chorion is fibrous and decidedly abnormal in appearance. Within the pedicle there are a few large blood islands.

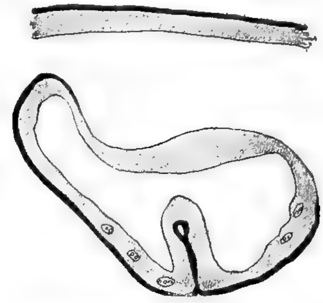
FIG. 1876.

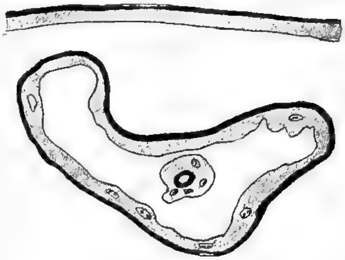
FIG. 1877.

FIGS. 1876 and 1877.—Sections through the Vesicle and Chorion of Specimen No. LXXXVII. × 25 times. A deeper portion of the invagination in Fig. 1876 is shown cut in cross section in Fig. 1877. Blood islands are in the mesoderm.

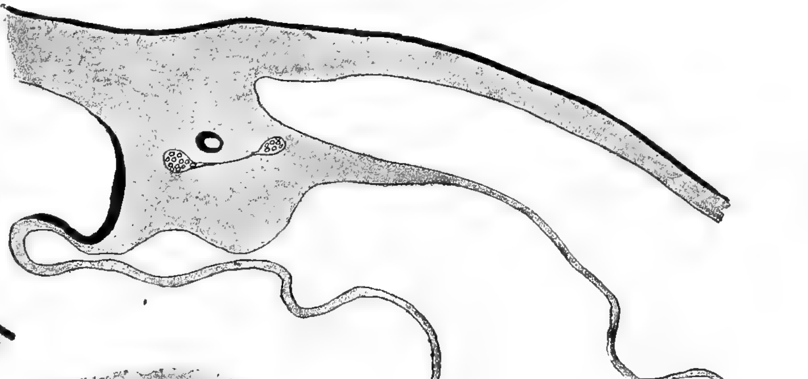
FIG. 1878.

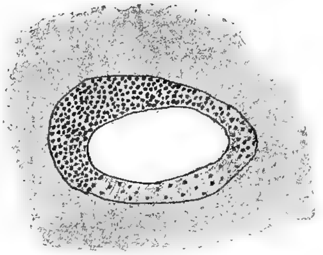
FIG. 1879.

FIG. 1878.—Sections through the Vesicle and its Attachment on the Chorion from Specimen No. LVIII. × 10 times. Within the stem there is a sharply defined cavity lined with epithelium and an hour-glass-like space filled with blood. On one side the stem is covered with epithelium.

FIG. 1879.—The Cavity of the Stem, shown in Fig. 1878, enlarged 50 times.

In the neighborhood of them there is a space lined with a sharp layer of epithelial cells which might be interpreted as an arrest of development of a stage like Graf Spee's v. H. On the outside of the pedicle, however, there is a distinct layer of epithelial cells, which brings this specimen in harmony with the others described above. My interpretation of this specimen is a partial formation of the amnion with most of the ectoderm on the outside of the vesicle. A similar condition is found in specimen LXXVIII., Figs. 1880–1882. Here again there is an epithelial layer around the periphery of the stem with a double amnion lined with high epithelium just beneath it (Fig. 1880). There are also blood islands in the mesoderm of the pedicle. Much more marked than any of the above is the condition found in XXIV., Figs. 1883–1885. We have here an ectoderm of varying thickness covering a large share of the vesicle, dipping into the depth at numerous points to produce solid plugs as well as invaginations. There are also numerous epithelial tubes within the pedicle which do not communicate with the outer epithelial layer. In this specimen we again have multiple amnion made intelligible from all of the specimens just described.

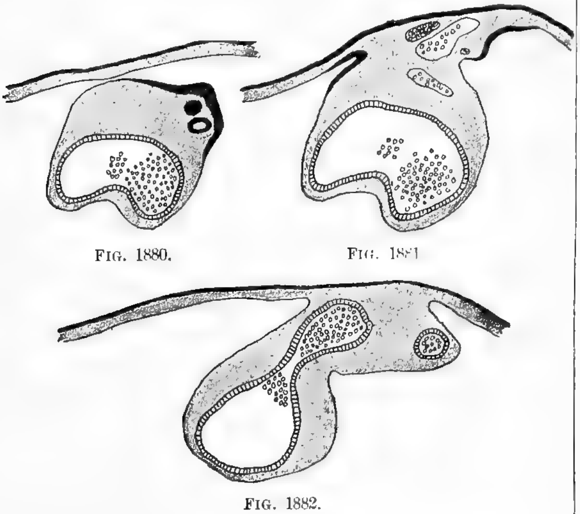

FIG. 1880. FIG. 1881

FIG. 1882.

FIGS. 1880, 1881, and 1882.—The Sections through the Vesicle and Chorion of No. LXXVIII. × 10 times. Blood within the cavity of the vesicle. The stem is partly covered with epithelium and there is a double amnion, shown in Fig. 1880.

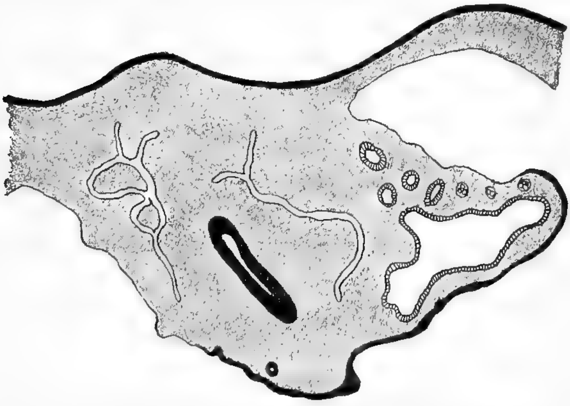

FIG. 1883.—Section through the Vesicle and Chorion of Specimen No. XXIV. × 25 times. There are a multiple allantois and multiple amnion with a thick layer of epithelium over the vesicle.

In addition to the specimen in which the amnion is either partial or multiple, we have in XIV., Figs. 1886 and 1887, a specimen without any amnion whatever. The vesicle is covered with a layer of epithelial cells (ectoderm) which has fallen off in part. There are a few blood islands present. There are also two spaces in the chorion which do not communicate with the main cavity of the vesicle and they are lined with a layer of thin cells. These may be remnants of the amnion, but their appearance differs so from the amnion in other specimens that I am not inclined to accept such an explanation. Below them, embedded in the chorion, there is a nest of syncytial cells.

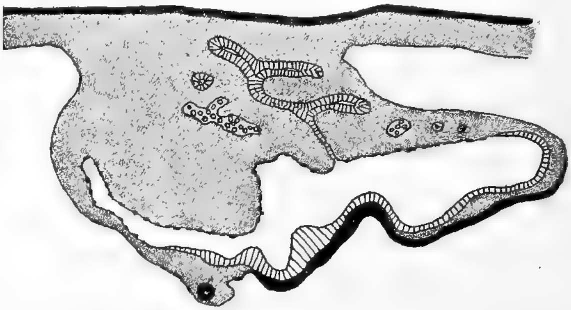

FIG. 1884.—Deeper Section through No. XXIV., showing the Branching Allantois.

With the hypothesis that the epithelial covering of the vesicle and the epithelial tubes in the stem are derived from the ectoderm, all of these pathological specimens of the vesicular form can be explained. I have constantly compared them with numerous sets of serial sections of normal umbilical vesicles of all ages, and have never found this epithelial covering of the umbilical vesicle of the normal embryo like that in the pathological. In one instance the umbilical vesicle of a pathological embryo of the fourth week (XCVII.) is covered with a layer of epithelial cells.

While we have all variations in the growth of the ectodermal covering of the vesicle, we also have variation in the growth of its entodermal lining. In general, there is a tendency for the pedicle of the vesicle to become destroyed, thus liberating the vesicle from the chorion. Hand-in-hand with this process there is an arrest of the development of the allantois. Usually there is none. My inclination is to consider the cavity in the pedicles of XIV. and XXI., Fig. 1886, as the allantois which has been separated from the umbilical vesicle. Yet this is only an opinion. In specimen LXXVIII. the cavity of the umbilical vesicle extends well into the chorion (Fig. 1882), and this condition may be viewed as dilatation of the allantois. In specimen XXIV., Figs. 1883, 1884, with the multiple amnion, we also have a multiple allantois. Its branches subdivide many times, as the figures show.

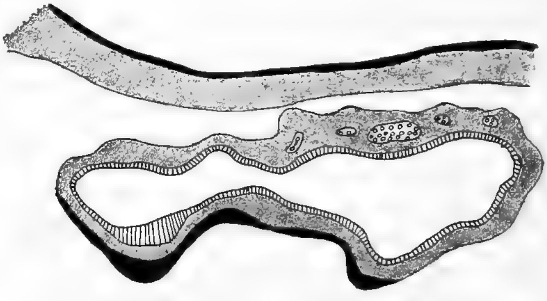

FIG. 1885.—A Deeper Section of the Vesicle, showing the Irregular Thickening of the Ectoderm and Entoderm.

In all the pathological specimens there are blood islands in the pedicle. This fact establishes the meaning of the vesicle. It is the remnant of the embryo and its umbilical vesicle. From it the blood-vessels grow to the chorion, and in all the pathological specimens of vesicular form they do not reach it. The same statement applies to all ova in which the embryo was destroyed at an early date. If the embryo is fairly well formed before it started to disintegrate, there are blood-vessels with or without blood in the chorion.

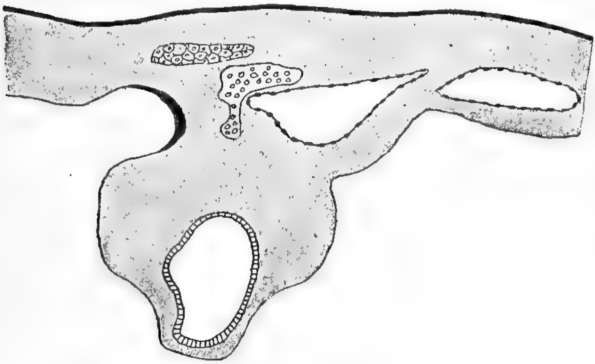

FIG. 1886.

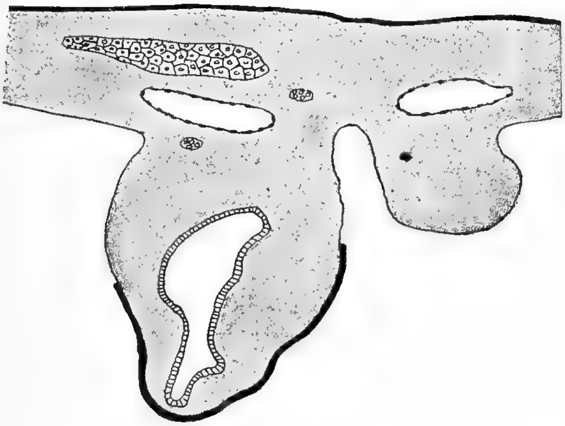

FIG. 1887.

FIGS. 1886 and 1887.—Section through the Nodule (Vesicle) of Specimen No. XIV. × 25 times. A few blood islands are within the stem as well as an enclosed mass of syncytium. These are also still in the chorion. The nodule is covered with a layer of epithelium which has fallen off at points.

What I have called umbilical vesicle is undoubtedly, in some instances, what Giacomini calls amnion in his earlier communications. The presence of blood-vessels is the main evidence for my calling these vesicles umbilical. The presence of an epithelial covering, especially in the neighborhood of the pedicle, its forming complete, partial, or multiple invagination into the vesicle or into its stem, are my main reasons for designating it ectodermal. Other observations, enumerated above, also speak for this interpretation.

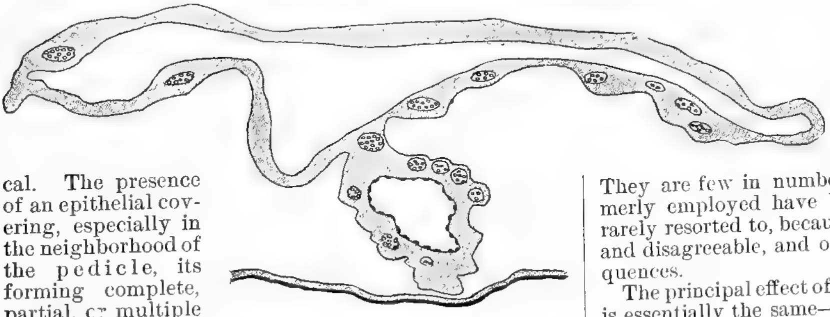

FIG. 1888.—Section through the Vesicle and Chorion in No. XXI. × 25 times. The second vesicle between the larger one and the chorion appears to be the stem with a dilated allantois, although it is not attached to the chorion.

A single vesicle just separated from the chorion is found in No. CXXIII., Fig. 1889. This vesicle is completely separated from the chorion with its pointed end opposite a pointed mound within the chorion showing its original connection. A similar vesicle is in specimen CXXX., but the communication may have broken off. Another specimen of the same kind is CXLVII. The vesicle is fully separated from the chorion and is partly covered with a very thick mesoderm in which are blood-vessels filled with blood. There are blood-vessels in the chorion in the immediate neighborhood of the vesicle, showing that at one time the vesicle must have been connected with it.

A unique specimen is shown in No. CXLIII. There are two large vesicles which do not communicate and are connected with the chorion. The structure of their walls could not be made out, as the specimen had been in alcohol many years. The vesicles seem to represent the amnion and umbilical vesicle.

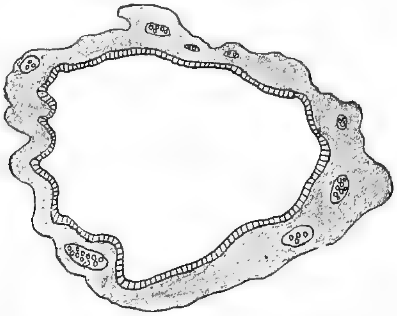

FIG. 1889.—Section through the Vesicle of No. CXXIII. × 25 times. Entoderm, mesoderm, and blood islands are shown.

The primary affection in the vesicular forms seems to be in the neighborhood of the pedicle. At this point all the forces come together. Through it the blood-vessels meet the chorion. Into it the amnion and allantois grow. So it is natural that forces which overthrow the development of an early embryo must express themselves at this point.

Franklin P. Mall.

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EMETICS are medicines used to produce vomiting. They are few in number. Some of the medicines formerly employed have become obsolete, and others are rarely resorted to, because their emetic operation is harsh and disagreeable, and often followed by injurious consequences.

The principal effect of emetics, the process of vomiting, is essentially the same—no difference by what means induced; but it may be preceded and followed by numerous phenomena which differ greatly in intensity and duration according to the agent used. These phenomena will be considered with the individual emetics. Here we may profitably study the common effect of emetics, the act of vomiting.

In order that vomiting may take place, certain muscles, whose action is consecutive in the normal state, must contract simultaneously. The efferent impulses coordinating, their movements come from the medulla oblongata, and are held to start in the emetic centre, which is closely related to the respiratory centre, but is doubtless more extensive. When this centre becomes excited in consequence of the action of a medicine, or of a morbid state of other organs, such as the stomach, uterus, peritoneum, meninges, cerebrum, etc., or of the blood, as in uræmia, efferent impulses pass from it to the various muscles whose simultaneous contraction is necessary in order that vomiting may take place.

However induced, by medicines or by pathological states, the process of vomiting usually begins with nausea and a flow of saliva, which is partly swallowed, often with much air. Soon retching takes place, an ineffectual effort to vomit, in which a strong inspiratory effort is made while the glottis is closed, so that no air can enter the lungs. The air being drawn into the pharynx, some of it is swallowed and helps to distend the stomach, thus facilitating the act of vomiting. Immediately after the inspiratory effort, and while the diaphragm is powerfully contracted and forced down toward the stomach, a strong contraction of the abdominal muscles occurs. Since the diaphragm remains contracted and the glottis closed, the whole force of this expiratory effort is spent in pressure upon the abdominal organs, and especially upon the distended stomach. Sometimes several successive retchings take place before the contraction of the abdominal walls becomes so powerful as to cause the ejectment of the contents of the stomach. When this latter happens the cardiac orifice of the stomach is widely dilated, which is supposed to be effected by contraction of the longitudinal muscular fibres of the œsophagus, especially those which pass from the end of the œsophagus over the stomach, but which more probably results from the diminution of the intrathoracic pressure necessarily following the powerful inspiratory effort while the glottis is closed. The intense action of the abdominal muscles, which causes the expulsion of the contents of the stomach, is quickly succeeded by a sudden and powerful expiration, which prevents the vomit from entering the glottis, and ejects mucus or other pathological products which may be present in the air passages.

During the contraction of the abdominal muscles the circulation of blood in the abdominal vessels is interrupted, and hence the vessels of the face, neck, conjunctiva, and probably of the brain, become distended.

The mode of action of most emetics is doubtful. Of one only, apomorphine, is it clearly proved that it acts on the emetic centre. Of ipecacuanha and tartar emetic it is not yet fully established how they act, whether on the emetic centre or on the gastric nerves, or both. It is generally held that sulphate of zinc, sulphate of copper, mustard, and alum act on the gastric nerves, though some authors hold that sulphate of zinc and sulphate of copper may also act on the emetic centre.

According to the supposed action of emetics, they have been divided into two groups: direct and indirect. Those supposed to act on the gastric nerves have been called direct emetics, and sometimes local, mechanical, or irritant emetics. The indirect emetics, which are supposed to act on the emetic centre, have also been called systemic emetics.

Apomorphinæ Hydrochloras.—The emetic action of this salt was observed by its discoverers, Wright and Matthiessen, in experiments, but Gee first investigated its operation on man. Numerous careful experiments on man and animals have been made since the discovery of its emetic power (1869), so that its mode of action and the incidental phenomena preceding and following its operation have been clearly elucidated.

It produces vomiting by acting on the emetic centre. This is evident from the fact that when injected into the subcutaneous tissue it acts more speedily, certainly, and in smaller doses than when given internally. That its operation does not result from elimination through the gastric mucous membrane is proved by the fact that intravenous injection is followed by vomiting in animals whose aorta has been previously ligated, so that no apomorphine can be conveyed to the stomach.

Apomorphine, in appropriate doses, acts speedily, certainly, and gently.

The time elapsing between the subcutaneous injection and the first act of vomiting may vary from two to twenty minutes, but it rarely exceeds ten minutes. In twelve careful observations by Riegel and Boehm the average time was nine and a half minutes after injection of the average dose of gr. $\frac{1}{9}$. In six other observations by the same physicians vomiting took place, on the average, in five and a half minutes after average doses of gr. $\frac{1}{8}$.

The emetic action takes place with great certainty, unless the dose is too small or too large, when it may fail. It may also fail in certain pathological states, especially in profound sopor produced by narcotics, and in severe dyspnœa with cyanosis. In these conditions it is supposed that the emetic centre is so greatly depressed that apomorphine cannot excite it.

Usually the action of apomorphine is gentle, and attended by slight incidental phenomena. Sometimes the vomiting occurs quite suddenly and unexpectedly, with very little effort, and without having been preceded by notable nausea or other symptoms. More frequently the act of vomiting is preceded for a short time, usually several minutes, by such phenomena as are incidental to the vomiting process however induced. There occurs slight nausea, with giddiness, ringing of the ears, and headache. Frequently there takes place a copious flow of saliva, with free perspiration. The patient may complain of some præcordial distress; or he may yawn, and become languid and sleepy. Retching soon takes place, and is rapidly followed by vomiting. In rare instances the patient during the period of nausea becomes restless, and presents motor disorder, such as rhythmical movements of the head, supination and pronation of the forearms, spasmodic movements of the lower jaw, and hiccup.

Before vomiting ensues the pulse becomes accelerated, but afterward slow. The blood pressure, according to Harnack, does not become increased, from which it is inferred that the frequent pulse results from excitation of the accelerator nerves. In some patients very little or no change in the pulse rate is observable. The respirations become rapid and superficial before vomiting, and afterward slow.

The act of vomiting, after an ordinary dose of apomorphine, may occur but once, or be repeated several times, occasionally from four to eight times. It is usually quick and easy if the stomach is distended, but preceded by ineffectual retching if the stomach is empty. Between the acts of vomiting, when they occur several times, the patient feels weak, yawns occasionally, and sweats freely. Sometimes copious salivation takes place. The nausea continues, often with eructations and retching. After the last act of vomiting nausea may persist for a short time; the patient is much relaxed, and usually very sleepy. The depression is rarely intense.

All the symptoms produced by apomorphine wholly disappear, as a rule, in from thirty minutes to two hours.

In young children appropriate doses generally cause vomiting very rapidly, the time elapsing between the injection and the first act of vomiting varying from three to seven minutes (Jurasz). In from one to three minutes the child exhibits evidences of its action. Usually it becomes more quiet, yawns occasionally, grows pale, and has a staring look. Infants not rarely present symptoms of depression; the head droops, the extremities become cool and powerless, the face very pale, the pulse feeble, and the general appearance resembles that of narcotic poisoning. According to Jurasz, these phenomena soon vanish after the cessation of vomiting. Then the child still perspires freely, and has a copious flow of saliva, but soon becomes sleepy, and usually goes to sleep. After several hours of rest it awakes fully restored to its ordinary condition. Thus the effects produced by apomorphine in infants are marked by greater depression than in adults. This is supposed to be due, not to a specific action of the medicine, but to the nausea, for which infants have great susceptibility and little endurance.

Sometimes alarming depression has followed moderate doses in adults. Thus gr. $\frac{1}{6}$ caused intense collapse in a strong man (Dujardin-Beaumetz). In the case of an old man gr. $\frac{1}{12}$ failed to produce emesis, but caused agitation, dimness of sight, small pulse, yawning, copious flow of saliva, and somnolency (Moeller). After doses of gr. $\frac{1}{20}$ to gr. $\frac{1}{15}$ a woman had repeated attacks of syncope, with alternating myosis and mydriasis, and convulsive twitchings of the corners of the mouth (Prévost). In young children appropriate doses sometimes produce spasmodic movements of the head, extremities, jaws, and diaphragm, with hyperæsthesia (Jurasz).

Excessive doses may fail to produce vomiting, and be followed by alarming symptoms, although generally they are not followed by severer symptoms than moderate doses. Professor Pecholier, after an injection of nearly gr. $\frac{1}{2}$, had ineffectual retchings, then suddenly became unconscious, and ceased to breathe. After another injection he vomited, and fell into a state of profound collapse, from which he was rescued by hypodermatic injections of ether and the application of sinapisms.

Apomorphine is appropriate in all cases indicating the use of an emetic. It should be employed whenever a speedy evacuation of the stomach is necessary, as in cases of poisoning, and when the stomach is inflamed, and hence liable to be injured by the irritant emetics. It is specially indicated when patients are unable or unwilling to swallow, as in trismus and insanity.

Apomorphine is administered hypodermatically. It never produces notable irritation, even when concentrated solutions are injected.

According to Jurasz and other observers, the following doses are suitable for children: From birth to three months, gr. $\frac{1}{120}$ to $\frac{1}{80}$; three months to one year, gr. $\frac{1}{80}$ to $\frac{1}{40}$; one year to five years, gr. $\frac{1}{40}$ to $\frac{1}{20}$; five years to ten years, gr. $\frac{1}{20}$ to $\frac{1}{12}$. For adults the dose varies from gr. $\frac{1}{12}$ to $\frac{1}{6}$. Females and weakly males require somewhat smaller doses, from gr. $\frac{1}{16}$ to $\frac{1}{8}$.

Generally one-per-cent. solutions are employed for adults, and one-half-per-cent. for children. The solution rapidly becomes green, but retains the emetic property for a long time. It is a good rule to remain with the patient for some time after the injection has been made, in order to apply restoratives should inordinate depression result.

Ipecacuanha.—As an emetic ipecacuanha is characterized by slowness and mildness of action. Its activity is due to the presence of an alkaloid, called emetine, which it contains in greatly varying quantities. Podwyssotzki found in the best kinds of ipecacuanha from three-fourths to one per cent. of emetine, and in the poorest only from one-fourth to one-half per cent.

The mode of action of emetine is doubtful. Most authors incline to the view that it results from an irritant action upon the peripheral termination of the vagus nerve in the stomach, because it acts, when given internally, in smaller doses than when injected subcutaneously, and just as rapidly, and because it has been discovered in the vomit after subcutaneous injection. Others hold that it acts on the emetic centre, because it causes vomiting after all modes of administration, internal, subcutaneous, intravenous, etc.; and because they failed to detect it in the vomit or any secretion or excretion after subcutaneous or intravenous injection (Podwyssotzki).

Ipecacuanha, or its active principle, emetine, acts slowly even when maximum doses are given. Rarely does vomiting occur before twenty minutes after doses of one scruple, and usually not before thirty minutes. Emesis results in about the same time after subcutaneous injections of emetine. When small or moderate doses of ipecacuanha are administered, vomiting may be delayed for a longer time. Thus Ackermann, in trials with ten-grain doses given at intervals of fifteen minutes, found that vomiting occurred in three-quarters of an hour. Sometimes, however, very small doses, two to five grains, act in twenty or thirty minutes. This is due in part to the varying quantities of the active principle, but more generally to the notable susceptibility of some persons to its action.

Even in very large doses ipecacuanha always acts mildly, the act of vomiting occurring but once or twice. Doubtless this is due to the expulsion of the greater part of the emetine before it can act upon the gastric nerves or become absorbed; for in animals, after subcutaneous injections of large doses of emetine, the act of vomiting is repeated three or four times at long intervals.

The incidental phenomena are usually slight. Sometimes the nausea is decided, and attended by marked general relaxation; and there may occur a copious flow of saliva, free perspiration, giddiness, shudderings, rapid pulse, eructations, and repeated retching before the act of vomiting; but these phenomena quickly subside afterward, the patient remaining only weak and sleepy for some time. Sometimes looseness of the bowels occurs, especially if the emetic operation is much delayed.

The quantity of ipecacuanha required to produce vomiting varies greatly—in some patients one or two grains sufficing, in others less than twenty or thirty grains not succeeding. Emetine usually acts in doses of one-twelfth to one-sixth of a grain. According to Husemann it more frequently than ipecacuanha causes loose stools.

Ipecacuanha may be employed in all cases requiring emetics, if speedy action be not necessary. It has usually been preferred to other medicines when irritating substances, such as indigestible articles of food, required removal, or when accumulations of mucus in the bronchial tubes were impeding the respiratory process. On account of its gentle action it is especially suitable for feeble, old, and very young patients.

For adults the dose of ipecacuanha varies from ten to twenty grains, repeated at intervals of ten or fifteen minutes until vomiting occurs. Generally it is given in the form of powder, mixed with an equal quantity of sugar. For very feeble patients the wine is preferable, which may be given to adults in doses of half an ounce. Large draughts of tepid water, taken as soon as nausea begins, hasten the emetic operation. To infants and young children the syrup of ipecacuanha is usually administered in doses of half a drachm to two drachms every ten minutes until vomiting results.

Antimonii et Potassii Tartras.—Tartar emetic is noted for severity of action, and hence is rarely employed except in combination with ipecacuanha.

Small doses act slowly. In careful trials, Ackermann found that half a grain, repeated at intervals of fifteen minutes, produced vomiting in one hour and three-quarters. But doses of one or two grains frequently operate within fifteen minutes. Often purgation follows, especially when the vomiting takes place slowly.

The incidental symptoms are very pronounced. They consist of intense nausea, profound muscular relaxation, pallor of the face, shudderings, free perspiration, giddiness, copious salivation, distress in the epigastrium, eructations, and severe, often violent, and frequently repeated, retching. The act of vomiting is usually repeated a number of times, at intervals of various length. Sometimes it occurs so often, and is attended by such severe nausea and retching as to cause profound collapse, marked by deathly pallor, sunken features, superficial breathing, and weak thready pulse.

Most authorities hold that tartar emetic produces vomiting by acting on the gastric nerves. The fact that it causes vomiting when injected into a vein, or into the connective tissue, does not prove that it acts on the emetic centre, for the quantity required to produce vomiting when thus administered is larger than the internal dose, and it acts more slowly. Besides, the medicine may be detected in the vomit after subcutaneous or intravenous injection, and hence comes into close relation with the nerves of the stomach. When tartar emetic is given internally, the greater part is discharged with the vomit, and the part retained or absorbed is insufficient to cause emesis when injected into a vein.

There exist no special indications for the use of tartar emetic. Formerly, when it was supposed to exert a controlling influence over inflammatory affections, it was often given at first in emetic doses. But this practice is now obsolete. It should never be administered to very young children, to aged or weakly patients, on account of the profound collapse which it may induce.

The hyperemesis which sometimes results from tartar emetic may be allayed by giving small pieces of ice with a few drops of chloroform. The following remedies are also useful: strong coffee, tannic acid, ether, wine, alcohol, morphine, and tincture of opium.

The dose of tartar emetic for adults is from half a grain to one grain, repeated twice if necessary. It is usually combined with ipecacuanha: ℞ Antimonii et potassii tartratis, gr. ij.; pulv. ipecacuanhæ, ʒ i. M. Div. in partes æquales, iv. Sig.: One powder every ten minutes until vomiting takes place.

Zinci Sulphas.—This salt, in suitable doses, produces vomiting promptly, energetically, and with little nausea. In some instances it also causes colicky pain and liquid stools.

According to the observations of Toulmouche, vomiting rarely occurs after the administration of two grains, inconstantly after four grains, almost always after six to twelve grains, and only in one-third of the cases after fifteen grains. Liquid stools occur in one-half of the cases after four to twelve grains, and in two-thirds of the cases after fifteen grains.

Sometimes, however, it operates in doses of one scruple to half a drachm, almost as soon as it reaches the stomach, causing a single but copious ejectment.

On account of its rapid action and the absence of notable nausea, sulphate of zinc is adapted to cases requiring speedy evacuation of the stomach. Hence it is usually employed in narcotic poisoning.

To adults it is given in doses of six to twelve grains, repeated, if necessary, every ten minutes until vomiting ensues. ℞ Zinci sulphatis, amyli, āā ʒ ss. M. Div. in partes æquales iij. Sig.: One powder every ten minutes until vomiting is induced.

Cupri Sulphas.—This salt, like the sulphate of zinc, usually acts promptly and without marked nausea. Its emetic action is also frequently followed by colic and liquid stools.

While the action of sulphate of copper is generally rapid, occurring soon after administration, it is sometimes quite slow. Thus Ackermann found that five-grain doses, administered every fifteen minutes, caused vomiting in one hour. Formerly, when sulphate of copper was used as an emetic in the early stage of phthisis, it was frequently observed that its operation was delayed for more than half an hour (Thompson).

Sulphate of copper is preferable to other emetics in poisoning with phosphorus, because it possesses antidotal properties. It gradually becomes reduced by the phosphorus, and then covers the phosphorus with a layer of metallic copper, and thus prevents its volatilization and absorption (Bamberger).

Sulphate of copper has been especially recommended in croup. If the exudation impeding respiration be loosely attached, the powerful operation of sulphate of copper may cause its expulsion; but it can produce no other effect.

The dose of sulphate of copper for adults is from two to ten grains; for children, from one to five grains, repeated, if necessary, several times at intervals of ten or fifteen minutes. ℞ Cupri sulphatis, ℈i.; pulv. acaciæ, ℈ij. M. Div. in chart. iv. Sig.: One powder every ten minutes until vomiting ensues (in narcotic poisoning). ℞ Cupri sulphatis, gr. vi.; aquæ destill., ℥ i.; syrupi, ℥ ss. M. Sig.: A dessertspoonful every ten minutes until vomiting ensues (in croup).

Sinapis Alba.—Mustard in large doses rapidly induces vomiting. When other emetics and the stomach pump are not at hand, it is employed in poisoning with narcotics. Sometimes it acts promptly when sulphate of zinc has failed. It should not be used when the poison is of such a nature as to produce inflammation of the stomach.

A teaspoonful of mustard flour may be administered in a teacupful of tepid water, and, if necessary, repeated once or twice at intervals of ten minutes.

Alumen.—Alum, in doses of half a drachm to two drachms, produces vomiting in from twenty to forty minutes. Its operation is attended by very little nausea and depression. It has sometimes been employed in croup and in narcotic poisoning. For children the dose is half a drachm administered in syrup, and repeated, if necessary, in half an hour.

General Indications for the Use of Emetics.—Emetics are used to evacuate the stomach, to expel pathological products from the air passages, and to remove foreign bodies lodged in the œsophagus or upper part of the air passages.

1. To evacuate the stomach is the first indication in many cases of poisoning. As it is essential to accomplish this as speedily as possible, only those emetics should be used which act promptly. In poisoning by narcotics, such as morphine, opium, atropine, belladonna, stramonium, etc., one of the following emetics should be selected: apomorphine, sulphate of zinc, sulphate of copper, or mustard. The subcutaneous injection of apomorphine is quickly followed by copious vomiting, if the nervous centres are not greatly depressed. Hence, if a long time has not elapsed since the poison was taken, and profound sopor has not taken place, this emetic should be preferred to all others. But if the patient is so comatose that he cannot be aroused, apomorphine should not be used, as it would probably fail to induce vomiting and would greatly increase the depression.

If some time has elapsed since the poison was taken, vomiting is not readily induced. Then sulphate of zinc and sulphate of copper may fail in ordinary doses; hence some authors recommend very large doses, from twenty to forty grains. It is well to recollect, however, that according to the observations of Toulmouche, doses of fifteen grains and more of sulphate of zinc more frequently fail than doses of six to twelve grains. It should also be recollected that large doses of sulphate of zinc and of sulphate of copper, if they do not cause emesis, produce severe irritation of the intestinal mucous membrane, and, after absorption, depress the central nervous system. If moderate doses do not soon cause vomiting, recourse should be had to mustard flour, which generally acts promptly.

In poisoning with phosphorus, sulphate of copper is preferable to other emetics, as it prevents the volatilization and absorption of the poison.

In poisoning with strychnine or nux vomica, apomorphine is the most suitable emetic. In several instances the spasms produced by strychnine have immediately subsided after a hypodermatic injection of apomorphine.

Apomorphine has been successfully employed in cases of poisoning with oil of bitter almond, with carbolic acid, and with kerosene.

Emetics are contraindicated in poisoning with corrosive substances, such as the concentrated mineral acids and the caustic alkalies.

Whenever emetics are employed in cases of poisoning by vegetable and animal substances, repeated emesis should be produced, as it is not rarely found that the vomit of the third or fourth evacuation gives evidence of the presence of some of the poison. In order to hasten and facilitate the action of the emetic, large quantities of tepid water should be given, and the fauces titillated with the finger or a feather.

Emetics are indicated to evacuate the stomach when indigestible food, or the products of fermentation or putrefaction, cause severe gastric irritation or alarming disorder of the nervous system. Sometimes convulsions in children, a comatose state in adults, intense headache, and severe cramp-like pain in the stomach, have this origin. If the history of the illness and the general condition of the patient clearly point to this cause, emetics should be used. They usually give speedy relief. The best internal emetic is ipecacuanha, as it produces less irritation of the gastric mucous membrane than sulphate of zinc, sulphate of copper, or mustard. Large quantities of tepid water should be given as soon as nausea supervenes, in order to render the vomiting as easy as possible. A subcutaneous injection of apomorphine is, however, superior to all internal emetics, as it in no wise increases the irritation of the stomach and causes speedy evacuation. Especially should it be preferred to ipecacuanha when convulsions in children are caused by gastric irritation.

2. To expel pathological products from the air passages, emetics are occasionally indicated in bronchitis, bronchiolitis, catarrhal pneumonia, and croup. When respiration is difficult, rapid, and superficial, and moist râles are heard over various parts of the chest, emetics often give decided, although temporary, relief. Apomorphine is preferable to other emetics, as it possesses decided expectorant properties and acts rapidly and gently. It may, however, fail in capillary bronchitis, when the breathing is very difficult and decided cyanosis has taken place. The only internal emetic which should be administered to children to eject accumulations of mucus in the air passages is ipecacuanha. In strong adults this remedy may be combined with tartar emetic.

Emetics are generally resorted to in croup to expel the fibrinous exudation or false membrane. Sometimes they accomplish this, but more frequently fail on account of the firm attachment of the membrane. If the ejectment takes place, a notable amelioration of the dyspnœa immediately occurs. As it is of the highest importance to prevent the depression which so rapidly occurs in croup, only those emetics are eligible which produce slight nausea, such as sulphate of copper, sulphate of zinc, and alum. Apomorphine has been successfully used in some cases, and in the early stage of croup deserves preference to other emetics.

3. Sometimes emetics are indicated when foreign bodies have lodged in the œsophagus and upper part of the air passages. They are useful when the substance lodged in the œsophagus is rounded, doughy, or pulpy, but may be harmful when it is very irregular (pieces of bone, needles, fish bones), as the efforts incident to vomiting may be followed by severe injury of the œsophagus.

When foreign bodies lodge above the glottis, they may be expelled by emetics; but if situated below, vomiting may cause them to lodge in the rima glottidis, especially if they be angular.

Apomorphine should be preferred to all other emetics to remove foreign bodies, as it acts speedily and certainly.

Contraindications.—At the time, now happily past, when it was supposed that the whole course of febrile and inflammatory diseases might be favorably modified by the action of emetics, especially by such as induce severe and prolonged nausea, authors found it necessary to enumerate numerous contraindications, such as inflammation of any of the abdominal organs, diseases of the heart and blood-vessels, great debility, the extremes of life, pregnancy, the presence of hernia, etc. When the presence of a poison in the stomach indicates its rapid evacuation, an emetic must be given regardless of all other considerations, if the stomach pump cannot be used. But in cases of gastric irritation in which life is not imperilled, other less rapid methods of treatment should be instituted, if the operation of vomiting itself endangers the life or future well-being of the patient.

Samuel Nickles.

EMETINE. See *Ipecac.*

EMMENAGOGUES. See *Ecbolics.*

EMODIN. See *Buckthorn* and *Cascara Sagrada.*

EMOLLIENTS (from Latin *emollire*, to soften) are substances which tend to soften, relax, and protect the parts to which they are applied. As a rule they are fatty and have very little, if any, real medicinal activity; but this lack of active medicinal virtue in no way detracts from their therapeutic value. Emollients are "for outward application" only. Substances of a similar kind, but for *internal* use, are called demulcents, and these two terms must be kept distinct. Demulcents are for mucous membranes; emollients for the skin. (See article *Demulcents.*)

Action and Uses.—The action of emollients is almost entirely mechanical; by their moisture and warmth they cause the blood-vessels to dilate, and with relaxation of contractile tissues pressure on the nerves is lessened, and thus the tension and pain in an inflamed part are relieved. Emollients also exert a *protective* influence over inflamed surfaces which would otherwise suffer from friction and even from the oxygen of the air; in cases in which the skin is broken, or the epidermis stripped off, the process of repair can go on without let or hindrance under the protective covering of an emollient. The judicious use of emollients is also responsible for the exclusion of many pathogenic organisms which would otherwise find an easy entrance through a broken skin, and which, having once gained admission, would do more than ordinary harm in tissues whose powers of resistance were already enfeebled. Without emollients wounds, burns, and superficial inflammations would heal but slowly; by emollients the skin is often preserved from cracks, chaps, and fissures, and should these unfortunately supervene emollients are the best remedial agents we have. The application of emollients to those surfaces of the body which come in contact, as the thighs, will lessen the friction and increase the comfort. Emollients also tend to prevent bed-sores and heal blisters; they are also useful in some forms of skin diseases, such as eczema.

List of Emollient Substances.—The chief are: Almond oil, cacao butter, castor oil, cold cream, glycerin, goose grease, lanolin, lard, liniments, linseed oil, neatsfoot oil, olive oil, paraffin, petrolatum, soap, spermaceti, suet, vaseline. Care must be taken to avoid using *rancid* fat or oil, for this would act as an irritant, and do more harm than good. Other substances, as collodion, white of egg, etc., act as *protectives*, but are not emollients. Poultices made of substances retaining heat and moisture are sometimes grouped with emollients, or even regarded as emollients, but they are not rightly included under that heading.

R. J. E. Scott.

EMPHYSEMA OF THE LUNGS.—*Definition.*—Emphysema is the condition in which there is dilatation of the air vesicles with atrophy of the alveolar walls.

Strictly speaking there come under this definition three forms of the disease: Hypertrophic or large-lunged emphysema, atrophic or small-lunged emphysema, sometimes known as senile atrophy, and local or compensatory emphysema. In addition to these forms it is convenient to consider here certain other conditions to which the term emphysema is applied, viz., acute vesicular emphysema and interstitial emphysema.

I. Hypertrophic Emphysema (Syn. *Large-Lunged Emphsema*).—*Morbid Anatomy.*—The lungs are large and distended and do not collapse when the chest is opened. The borders are rounded, encroaching on the heart, sometimes meeting and even overlapping beneath the sternum; the apices project far above the clavicles and the diaphragm is depressed by the voluminous lungs. In color the organs are of a pale gray or grayish-red, and often streaked with lines and spots of pigment. The outlines of the lobules are more distinct than in health, and on close observation the individual air cells appear as clear dilated vesicles reaching the size of small shot or somewhat larger; in occasional instances large thin-walled blebs or bullæ form from the union of smaller vesicles and reach the size of a cherry or walnut. To the feel the organs are soft and downy, they pit on pressure owing to loss of elasticity, they do not crepitate like healthy lungs, and when placed in water they float higher than usual.

These changes, although they may be generalized, are seen earliest and reach their highest development in those areas of the lungs which are unsupported by firm and resisting portions of the chest wall. They are thus best seen at the apices, along the anterior borders, especially on the left side, at the lingula and at the bases of the lungs, particularly at the free borders and on the left side where the firm support of the liver is lacking.

Microscopically the alveolar walls are much thinned and the vesicles and infundibula are much enlarged. Rindfleisch has shown that extensive anastomoses take place between the pulmonary arterioles and the veins.

The bronchi frequently show evidence of chronic catarrhal inflammation, a condition which, as will be presently seen, is a frequent precursor of emphysema.

In rare instances rupture of the thinned-walled vesicles may occur and an escape of air take place into the pleura, producing pneumothorax, or into the cellular tissue of the lung or mediastinum, whence it may reach the subcutaneous tissues of the neck and thorax and cause subcutaneous emphysema.

Changes in the right heart are commonly seen in advanced cases of emphysema. Owing to the increased strain thrown on the right ventricle as the result of the occlusion of large areas of capillary vessels, dilatation-hypertrophy sets in primarily on this side, leading to tricuspid regurgitation and ultimately to the same train of morbid changes, consisting in chronic congestion of the various viscera, as are seen in cases of chronic heart disease. The main branches of the pulmonary artery sometimes undergo chronic sclerotic changes, the result of long-continued high arterial pressure.

Pathogenesis.—Much discussion has centred about the pathogeny of emphysema, and the chief theories of its production may be briefly discussed under three heads.

1. Inspiratory Theory.—Laënnec first advanced the view that emphysema occurred during inspiration owing to the inspiratory movements being more powerful than the expiratory. Gairdner subsequently developed this theory of emphysema and put forward a hypothesis which is still regarded as correct but only in a very limited sense. According to this writer diminution in the volume of the lung, due to collapse from bronchitis or broncho-pneumonia, or again recession from fibroid change, precedes the development of emphysema, and the adjacent air vesicles dilate to take the place of the collapsed areas. That such a sequence does occur is generally admitted in the development of local or compensatory emphysema, but it is regarded as of altogether secondary importance in the production of the form of the disease now under discussion. Gairdner's suggestion that the inspired air expanded in the air vesicles under the influence of the body heat hardly needs refuting, as it is now well known that the inspired air is heated in the nasal cavities.

2. Expiratory Theory.—Jenner (Med.-Chir. Soc. Trans., vol. xi.), although preceded by Mendelssohn, independently advanced the view that emphysema was produced chiefly by forces acting during expiration. He showed that during violent expiratory actions, such as cough or straining efforts, certain portions of the lungs being unsupported by rigid parts of the chest wall, yield and dilate under the influence of expiratory forces, and that the apices, the anterior borders and the bases, especially along their free margins, are exactly those parts which are least supported and which are affected earliest and in the highest degree by emphysema. In support of his view Jenner pointed out the bulging that takes place at the apices during an attack of cough, especially when the lung is affected by emphysema, and he also quotes Louis as his authority for the statement that the base of the left lung is affected by emphysema twice as often as the right, owing to the absence of the firm support afforded by the liver.

The frequency of emphysema in old-standing cases of bronchitis is readily explained by the application of Jenner's views. During the accompanying cough a deep inspiration is taken, the glottis is closed, and a violent expiratory effort is brought about by the muscles of expiration, compressing the lung and causing dilatation of these organs in the parts referred to. A similar mechanism comes into play during the severe muscular efforts caused by such movements as lifting or dragging heavy weights, straining at stool, or playing on a wind-instrument.

The emphysema which is so frequently seen in old cases of asthma is not so readily explained. The bronchitis and cough which are such common accompaniments of asthma are undoubtedly responsible in great part, inducing emphysema by expiratory efforts as in bronchitis, but this hardly seems the whole explanation. During an attack of asthma a temporary emphysema frequently develops, particularly when the attack is prolonged or severe, and passes off as it subsides. The enlargement and fixation of the chest in the inspiratory posture, together with the noticeable difficulty in expiration, indicate difficulty in expelling air from the chest, and in consequence the alveoli become overfilled. Accepting the usual view that asthma is due to obstruction of the smaller tubes, resulting from spasm or catarrh, it is assumed that the resistance to the exit of air is greater than to its entry, and in consequence the alveoli gradually become distended.

3. Vital Causes.—Most clinicians agree that emphysema is occasionally found when no apparent cause has been in operation or when the history of cough or other cause has been slight or of short duration. In such instances it is assumed that there is a congenital deficiency in the quality of the lung tissue, allowing it to yield under the ordinary strain to which it is of necessity subjected. In support of this view it may be urged that emphysema is not uncommonly found in several members of a family, and a number of observers have recorded a marked hereditary tendency in the disease.

Cohnheim has endeavored to show that a defective development of elastic tissue underlies the production of emphysema, but a deficiency in this tissue may simply represent the atrophy accompanying the morbid process.

Summing up, then, the conditions tending to produce emphysema we must attribute special weight to violent expiratory efforts. Owing to the yielding character of certain portions of the thoracic cavity the air is compressed and driven into the underlying alveoli, which dilate and ultimately become emphysematous. In this form of emphysema inspiratory causes, apart from the possible inspiratory distention caused by asthma, play no part, and lastly, whilst it seems probable that as in other tissues there may be a lack in resisting power, we have no definite anatomical knowledge in what this consists.

Etiology.—Age. Emphysema occurs at all periods of life, but it is more frequently found in adults beyond middle life, although it occurs even in young children.

Sex. Males are more exposed to the causes favoring the development of emphysema, and it is consequently more frequent in this sex than in females.

Occupation. All occupations involving exposure and catarrhal affections or heavy straining efforts tend to produce emphysema by causing violent expiratory efforts. It is thus found more amongst the laboring than the leisure classes.

Previous Diseases. Of all the causes of emphysema chronic or recurring bronchitis is by far the most common. It is indeed unusual to find old-standing cases of this nature without some accompanying emphysema. In children the cough of pertussis and of the pulmonary lesions associated with measles are occasional factors in the development of the disease, and Osler remarks on the frequency of emphysema in the asthmatic attacks associated with adenoid growths. In chronic cardiac disease and in arterial sclerosis with its accompanying cardiac and renal lesions emphysema is often seen.

It is probable that inflammatory changes in the lung sometimes lessen its resisting power and favor the production of emphysema. A case of Hertz's is quoted by Hilton Fagge, in which emphysema rapidly developed in a cornet player after an attack of double pneumonia.

Symptoms.—The onset of emphysema is slow and insidious, although it occasionally develops rather rapidly after an attack of bronchitis or whooping cough. No special symptoms are noticed in the earlier stages of the malady, although there is a frequent history of chronic or recurring bronchitis.

Dyspnœa is by far the most important and prominent feature of the malady. The patient notices after any unusual effort that he suffers somewhat from shortness of breath. The difficulty is aggravated by every slight attack of bronchial catarrh. As the disease advances the dyspnœa increases and there are paroxysmal attacks like asthma, especially with any accession of catarrhal trouble, and are accompanied by wheezing, prolonged expiration, and orthopnœa. Eventually dyspnœa becomes more constant and present even at rest, the patient sits propped up by pillows or in an armchair, and the slightest exertion is accompanied by an increase of dyspnœa.

A slight tinge of lividity about the lips and finger nails is present, indicating deficient aeration of blood, and in advanced stages there may be a most intense degree of cyanosis. With this, however, the patient may not be incapacitated for slight exertion, and as Osler remarks there is hardly any other condition in which a patient may go about and even walk to a hospital with a lividity of startling intensity.

Hæmoptysis is not often noticed in emphysema, and when present is suggestive of a complicating tuberculosis. Recurring hemorrhages have, however, been observed, and although usually slight, have been known to be severe and even to prove fatal.

Cough and expectoration, strictly speaking, depend on associated bronchitis, but many individuals, in whom bronchitis is a subordinate feature, suffer from a slight cough and expectorate clear perles of mucus.

The course of the disease is usually progressive. The symptoms are much aggravated during attacks of bronchitis, and each attack tends to increase the emphysematous condition and the distress of the patient. Dilatation of the right heart may still further aggravate the dyspnœa and distress of the sufferer; œdema of the lower extremities, albuminuria, and signs of portal obstruction set in and the clinical picture is that of advanced cardiac disease. There is dilatation of the veins of the neck and sometimes pulsation indicating tricuspid regurgitation.

Although there is commonly some failure in general nutrition in emphysematous patients, it is only in the terminal stages of the disease that emaciation becomes at all marked. Clubbing of the finger nails is less frequent than might be anticipated, occurring, according to Esbach, only once in six cases.

Physical Signs.—The recognition of the disease rests on the presence of certain physical signs. In a well-marked instance the appearance of the chest is very characteristic. The thorax is rounded or barrel-shaped, the antero-posterior diameter is increased, and a cyrtometer tracing may even show that it exceeds the transverse. The clavicles are prominent, the supraclavicular and infraclavicular fossæ are deeper than usual, the shoulders are rounded, and the back is convex, causing the scapulæ to assume a more horizontal position. The thorax is in fact fixed in the inspiratory position, and the sternomastoid and trapezius muscles are prominent and hypertrophied. The first and second pieces of the sternum sometimes form a prominent angle, known as the angle of Ludovici, the bone being convex from above down; the intercostal spaces are wide, whilst the projection of the lower ribs gives the abdomen a hollow appearance. There is very slight inspiratory movement, the tape measure showing a movement often not exceeding one-quarter or one-half an inch.

The vocal fremitus is somewhat diminished as is also vocal resonance.

Whilst the above signs are present only in well-marked cases of the disease, by means of percussion even slight degrees of emphysema can be detected. The resonant areas of lung are increased, and instead of cardiac dulness beginning at the fourth rib it is found at a lower level and may indeed be altogether replaced by pulmonary resonance which passes into the tympany of the stomach. The liver dulness is also lower than usual, and in marked instances may be completely replaced by pulmonary resonance. Although displaced downward, it is only seldom that the hepatic border can be palpated owing to the arching forward of the lower ribs already referred to. In the back the resonant note of the lungs is also lower than usual, reaching as low as the lower border of the twelfth rib. Not only are the resonant areas of the lungs increased in extent, but the character of the note is changed, becoming louder and deeper than normal, and in some instances it is even tympanitic.

On auscultation the breath sounds are distant and feeble, whilst expiration is frequently but by no means always prolonged.

The cardiac impulse is feeble owing to the presence of the lung between the heart and the chest wall, and both first and second sounds are often much enfeebled from the same cause. A systolic murmur is not very uncommon at the lower end of the sternum and sometimes indicates a tricuspid regurgitation. Increased pulsation in the epigastric region is often found due to the low position of the diaphragm, and it is sometimes intensified by enlargement of the right ventricle.

Diagnosis.—Emphysema is readily recognized by the characteristic shape of the chest and in slighter degrees of the affection by the increases in the resonant areas of percussion. A history of bronchitis should always suggest careful mapping out of the extent of pulmonary resonance. Emphysema is very apt to obscure the diagnosis of other affections within the thorax, and it may prove difficult or impossible to recognize an enlarged heart, an aneurism, or a tuberculous focus at the apex in the presence of marked emphysema. The diminution of the liver dulness sometimes leads to an erroneous diagnosis of cirrhosis, an error easily committed without a due appreciation of the increased area of pulmonary resonance.

Prognosis.—Emphysema is an extremely chronic malady, lasting for a long period of years. The prognosis is influenced largely by the frequency and severity of attacks of bronchitis, each of which tends to cause further damage to the lung tissue. In individuals who can afford to reside in a suitable climate and avoid attacks of bronchial catarrh the condition may be stationary. The condition of the heart and kidneys requires careful consideration. The outlook is not good when evidence of breaking down of cardiac compensation is present, and such serious signs as dropsy and albuminuria usually presage a fatal issue. Emphysema is a frequent accompaniment of interstitial nephritis and is in such instances altogether a subordinate feature, the prognosis resting on the condition of the kidneys.

Treatment.—Jenner truly remarks that as "emphysema is an incurable disease, its prevention is of the highest importance, and to determine its cause . . . is to determine to some extent the means to be employed for its prevention." It is of much importance to prevent frequent recurrences of bronchitis and to this end the various causes of bronchitis should be as far as possible avoided. If circumstances permit residence in a temperate and equable climate is to be recommended in winter and in the changeable and uncertain weather of the spring and fall. After the development of any degree of the disease it is of importance to avoid any occupation involving straining efforts as such are certain to aggravate the malady.

Patients with emphysema usually seek advice for attacks of bronchitis or asthma, and as the treatment of these conditions does not differ from that ordinarily adopted it is not necessary further to refer to them here.

The use of the compressed-air bath is highly spoken of by C. T. Williams, Fowler, and others. Dyspnœa is markedly lessened and the good effect continues after a course of baths. The lack of apparatus has hitherto prevented any extensive use of this mode of treatment. Expiration into rarefied air, carried out with the view of emptying the chest of residual air and so aiding expiration, has not been attended with such good results as the use of compressed air.

When symptoms of cardiac failure are present digitalis and strychnine are of value, and in cases of marked cyanosis and dyspnœa bleeding and the withdrawal of ten to twenty ounces of blood may be necessary.

It is of importance not to overload the stomach, as distention of the abdomen increases the difficulty of breathing and precipitates asthmatic attacks. An occasional dose of calomel or blue pill followed by a saline is of much value in relieving the portal circulation, particularly in plethoric subjects.

II. Atrophic Emphysema (syn. *Small-Lunged Emphysema, Senile Atrophy*).—This variety of emphysema is met with in old people and is really a senile atrophy of the lung, accompanied by some dilatation of the air vesicles.

The contrast between hypertrophic and atrophic emphysema is very striking, the only feature they have in common being some dilatation of the air sacs.

In atrophic emphysema the lungs are small and dark-colored from excess of pigmentary deposit. They can be compressed into a very small space and collapse when the thorax is opened. The bronchi share in the general atrophy and sometimes present evidences of catarrhal inflammation. Some of the air cells are enlarged, partly as the result of atrophy of adjacent alveolar walls, partly from the bronchial cough which is so common in advanced life. The other organs present the changes of senile involution.

Individuals who are the subjects of this condition are thin, old, and shrivelled-looking, and they do not suffer from any symptom which can be dissociated from the debility and failure of old age. Dyspnœa is absent owing to the general atrophy of the tissues causing a lessened demand for oxygen.

The thorax is diminished in size and the ribs lie more obliquely than usual, being closely packed together and the lower ones depressed so as to be near the iliac crest The shoulders are often rounded and stooping is therefore present. Percussion resonance is increased owing to the thin chest wall, but the cardiac dulness is not diminished and may even be increased owing to retraction of the lungs.

III. Compensatory Emphysema.—This form of emphysema results from disease of any portion of the lung in which the volume of the organ is diminished. It is seen constantly in the neighborhood of old tuberculous foci or of areas of collapse in broncho-pneumonia. With disease resulting in contraction of one lung the opposite side becomes emphysematous, this change being seen in its highest degree in the fibroid lung, and to a less extent in pleurisy or pneumothorax. In the earlier stages of the affection the air vesicles are simply dilated, but ultimately the adjacent alveolar walls atrophy and a permanent dilatation ensues. Gairdner's view that emphysema is due to inspiratory stretching of the air vesicles is probably in part the explanation of this form of emphysema, although the expiratory stretching due to cough, so rarely absent in pulmonary disease, doubtless intensifies the condition. When confined to a small area this form of emphysema is chiefly of pathological interest and may give rise to no physical signs. A hyperresonant note with feeble respiratory murmur and prolonged expiration over a limited area of lung is suggestive of the condition, and if present at the apex of a lung usually indicates a tuberculous focus.

Compensatory change in a healthy lung may be of the nature of true hypertrophy. It is indicated by an increased rather than diminished expansion, and by the presence of puerile breathing.

Acute Vesicular Emphysema.—In any condition in which extreme dyspnœa is present this type of emphysema develops. It occurs in the dyspnœa of cardiac or renal disease, in asthma and bronchitis, and in obstruction of the air passages.

There is only a temporary distention of the air vesicles, passing off with the cessation of the dyspnœal attack, and not going on to atrophy and destruction of the alveolar walls.

The condition is recognized by the extreme inspiratory distention of the thorax, by the increase of the resonant areas of the lungs, and by the hyperresonant note. Œdema is frequently present, evidenced by the crackling râles at the bases and by sonorous and sibilant râles over the chest.

The treatment is that of the primary condition.

Interstitial Emphysema.—This form of emphysema is rather rare and, clinically, is of but slight importance.

Air occasionally passes into the interstitial tissue of the lung from rupture of an air vesicle. This accident is seen after severe paroxysms of cough, and it is probable that such a condition not infrequently occurs and recovery ensues without any special symptoms. In some instances, however, the air passes along the connective tissue to the mediastinum and thence to the subcutaneous tissue of the neck and thorax, where it is recognized by the crepitating sensation conveyed to the fingers. On the other hand, the air may find its way down from a wound in the neck, beneath the deep fascia, and thence to the connective tissue of the lung. Money has recorded cases of tracheotomy wounds in which this complication arose, and in a few instances pneumothorax was induced by rupture of the pleura. *Frederick G. Finley.*

EMPHYSEMA, SUBCUTANEOUS (*ἐμφύσημα, inflation*; from *ἐν, in,* and *φυσάω, to blow*), also known as cellular or surgical emphysema, may be defined as a pathological condition in which air or other gases are either developed in or introduced into the cellular tissue beneath the skin. The cases of air or gases being *developed* in the tissues are infrequent, and are generally the result of decomposition, or come more appropriately under the head of gangrenous emphysema. We are here concerned with those cases in which the air is *introduced* into the tissues.

Etiology and Pathology.—The most common location of subcutaneous emphysema is the chest; and the causes may be divided into traumatic and pathological. The former may occur in any of the following ways: (1) The air cells of the lung may rupture from overdistention following violent expiratory effort of any kind, and, the pleura remaining intact, the air escapes into the cellular tissue between the lobules, thence by the root of the lung into the superior mediastinum, then to the cellular tissue at the root of the neck, and here becoming subcutaneous is capable of spreading over a large part of the body. It may cause dyspnœa, and, if very severe, prove fatal. (2) The lung may receive a wound (the chest wall remaining intact), as when it is lacerated by a fractured rib; in this case the air, on inspiration, passes into the pleura, and during expiration, the wound of the lung being closed by the valve-like action of the tissues, the air is pumped out and finds its way into the subcutaneous tissues. (3) A wound of the chest wall may penetrate the pleural cavity (and possibly the lung), and if the wound be narrow and of a valvular character, with the external and internal openings not opposite to each other, then during inspiration the air easily passes into the pleural sac, but on expiration the edges of the wound falling together cause "the valve" to close, and the air which cannot escape in any other way infiltrates the cellular tissue. (4) In a long, sinuous wound of the chest wall, which does not reach the pleura, air may be drawn into the tissues during inspiration, but, the wound closing during expiration, emphysema results. In the above cases, if the lung is wounded, there may or may not be a pneumothorax. If the wound happens to be at a spot where adhesions exist between the two layers of the pleura, there will be no pneumothorax. (5) Wounds of the trachea, larynx, or bronchi may produce emphysema. "Emphysema occurring at the time of the operation (*i.e.*, tracheotomy) is due to too small a skin wound or to opening up the cellular tissue in attempts to pass the tube; it may be very extensive and spread down into the thorax; in such cases it is sometimes fatal from pressure upon the lungs. Champneys (Med.-Chir. Trans., 1882) has shown experimentally that there is serious danger of mediastinal emphysema and pneumothorax when artificial respiration or sudden violent inspiratory effort is made after division of the deep cervical fascia; hence the tube or dilator should be put in quickly and the fascia disturbed as little as possible." (Ashby and Wright: "Diseases of Children," Am. ed., 1893, p. 186.) Emphysema may also follow paracentesis thoracis, but is generally slight, though severe cases are not unknown. "Erichsen mentions a case in which the scrotum became blown out to the size of a cocoanut five minutes after a puncture of the chest, in which the patient coughed violently") (*Lancet*, 1889, i., 220). In the head we may have orbital emphysema from fracture of one of the thin orbital bones and the establishment of a communication with one of the air-containing cavities. In the abdomen emphysema has been caused by rupture of the duodenum or perforation of the cæcum.

SYMPTOMS.—History of the injury. Disability, varying with the degree and location of the hurt. Painful constriction of the chest at the seat of the lesion, with dyspnœa and tendency to suffocation. The chief symptom is the swelling, which has little or no discoloration, is possibly pale, is not painful, has no sense of weight, on pressure it pits but slightly and the pitting is very transient, but there is a peculiar and unmistakable crepitation or crackling which is pathognomonic of this condition. The swelling begins at the seat of the lesion (but when it is first seen at the root of the neck it is caused by rupture of the lung) and increases rather rapidly, its size varying somewhat with the laxity of the subcutaneous tissues; it is mostly limited to the trunk and neck, though occasionally it may extend over the greater part of the body. In severe cases the air may separate the fascia and penetrate between and below the muscles. The palms and soles and also the scalp generally escape. When the swelling is very small, it is lobulated, and by pressure the air can be driven out. An external wound can generally be found when the air has entered from without; if from within, an expiratory effort will cause the swelling rapidly to increase in size. On the face, the features may be obliterated, and the eyes hidden by the swollen lids.

PROGNOSIS AND TREATMENT.—The prognosis is as a rule quite favorable: the air generally becomes absorbed rapidly and completely; only rarely inducing inflammation. The danger is in the pressure, or in the pneumothorax, with which emphysema is often associated. Care must be taken to prevent sepsis. If absorption do not take place, we may try pressure by means of strapping or bandages; these failing, we try multiple punctures or incision. Antiphlogistic measures are in order.

Subcutaneous emphysema appears to have attractions for others besides the physicians. In Europe it is artificially induced by malingerers, by mendicants, by prisoners, and those who from lack of patriotism or some other cause do not wish to serve in the army. These enterprising individuals by means of a small wound inflate the subcutaneous tissues and then produce a deformity which, though transitory, may possibly serve their purpose and excite the sympathy if not the admiration of the more honest and hard-working portion of the community.

Fifteen years ago Dr. Silvester, in the *Lancet* (1885, i., 11; ii., 418), suggested the self-induction of subcutaneous emphysema as a method of "life-saving from drowning"; but the idea does not seem to have been generally accepted.

R. J. E. Scott.

EMS.—This well-known spa, about 70 miles from Cologne viâ Coblenz, is beautifully situated in the narrow valley of the River Lahn, at an elevation of 300 feet. On both sides of the river rise precipitous and forest-covered mountains. It exhibits all the characteristics of a spa town: numerous hotels, large and small, villas and lodging houses; the bath-houses with a magnificent Kursaal; public gardens admirably laid out, with a fine covered walk; bazaars, restaurants, cafés, and an English church.

The climate is a mild one, the average temperature of the year being 49.1° F., and for the summer, May, 57.9° F., June 64.6°F., July 66.2° F., August 63.5° F., September 57.9° F. The annual rainfall is 26.2 inches. The season extends from May 1st to September 30th. May and September are the pleasantest months; the summer is said to be rather too warm for comfort. The town contains about 8,000 inhabitants and about 22,400 persons visit it annually, among whom are many Americans, English, and Russians. Here one can lead a pleasant life with good music and good society. For many years the Emperor William I. was accustomed to take these waters, and it was here, on July 15th, 1870, that he made his memorable answer to the French ambassador which led to the war of 1870–71.

The warm waters of Ems have been known and used since the fourteenth century or even earlier, and flow from warm alkaline saline springs whose source is from a very compact sandstone which runs into quartzite; the temperature ranges from 80° F. to 120° F. The principal constituents are sodium carbonate, sodium chloride, and free carbonic acid; the Eisenquelle contains only carbonate of iron. There are eight or nine springs, all similar chemically but differing in temperature; those most used are the following, with their temperatures: Kesselbrunnen, 116° F.; Krähnchen, 96° F.; Fürstenbrunnen, 103° F.; Augusta, 102° F.; Victoria, 81° F.; Kaiserbrunnen, 83° F.

According to Buckland, the chief ingredients in sixteen ounces are as follows:

Bicarbonate soda	14 to 15 grains.
Chloride sodium	7 "
Bicarbonate lime	1 to 2 "
Bicarbonate magnesium	1 to 2 "
Carbonic acid gas	6 to 8 cu. in.

These waters are used principally for drinking, but they are also employed for the purposes of gargling, inhalation, and bathing.

The baths are well fitted up with apparatus for hot and cold douches and various other methods for water application. There are six public bath-houses with one hundred and eighty bath-rooms. One of the especial features in the utilization of these waters is the method of applying sprays to the throat, and the inhalation of finely pulverized water, either simple or medicated. There are also rooms for gargling; a milk and whey cure; and a "terrain kur." Massage is also given in connection with the baths. The waters are chiefly drunk between six and eight in the morning, and the "jour médical" is very much like that at other European spas.

A large quantity of this water is annually exported. From the town a wire-rope railway leads to the top of the wooded Malberg, 1,090 feet high, where are charming walks provided with convenient resting places; there are also numerous other attractive excursions in the vicinity. The accommodations are good and abundant, and the health reports are satisfactory.

The waters of Ems are employed in a variety of maladies, and, as is more or less the case in all carefully regulated spas, the hygienic-dietetic rules inculcated along with the use of the waters undoubtedly greatly increase their efficacy. Two-thirds of the patients who visit Ems are sufferers, it is said, from chronic catarrh of the nose, larynx, pharynx, and bronchi. Indeed, one of the unpleasant features of the place is the coughing and expectoration met with on all sides. Chronic bronchitis from measles or whooping-cough receives marked benefit from the treatment here. Chronic gastric and intestinal catarrh, hepatic congestions, atonic dyspepsia associated with anæmia, cystitis, gouty and rheumatic affections, especially the former; excessive nervous irritability, hypochondria, hysteria, paralytic affections of the limbs, are diseases which are treated more or less successfully at Ems. Skin diseases and scrofula are also in evidence here as at almost every other bath resort. The baths are extensively employed in cases of leucorrhœa, in catarrhal conditions of the uterus and cervix uteri, in nervous cases of dysmenorrhœa and in sterility.

Indeed, one sometimes wonders what chronic diseases that flesh is heir to are not benefited at such popular spas as Ems, according to the advocates of natural hydrotherapy. The comparative ease of access from Paris or England renders Ems very available for Americans; and its attractive situation in the vicinity of the Rhine invites the weary traveller to settle down there for a brief season, improve his metabolism by a course of water-drinking, diet, and rest, and then go on his way rejoicing in his renewed health and vigor.

Edward O. Otis.

ENCEPHALOCELE. See *Brain: Cephalocele.*

ENCHONDROMA. See *Chondroma.*

ENDARTERITIS. See *Blood-Vessels.* (*Path.*)

ENDOCARDITIS. See *Heart Diseases.*

END-ORGANS, NERVOUS.—While in origin all nervous structures may be said to have been derived from peripheral structures, in so far as the nervous elements are ectodermal rather than otherwise, yet in higher animals the separation of those elements that are aggregated within the body to form a central system from those which retain their primitive connection with epidermal structures is so complete as to warrant the division of nervous elements into central and end-organs.

End-organs fall likewise into two great classes depending on the origin of the stimulus they are designed to receive. Peripheral organs, properly so called, are such as are adapted to receive stimuli from without, as in the case of the sensory cells in the skin and organs of special sense (and this group cannot well be arbitrarily separated from the entirely similar organs of the æsthesodic system within the body) while kinesodic end-organs are such as are intended to deliver to organs like muscles and glands the stimuli elaborated in the central system. In addition, there is the system of somatic or sympathetic organs which serves to modify the function of one organ in accordance with the activities of others—a system of somatic equilibrium probably much more important than even yet supposed.

In this article the somatic or so-called sympathetic system is not included.

Peripheral End-Organs.—It would seem from the data of comparative anatomy that the progenitors of the vertebrates had sensory cells scattered among the epidermal elements in the skin, and that in the course of evolution there was exhibited a tendency for these cells to become collected toward the lateral and dorsal parts of the body and especially in the region of the future head.

Probably Van Gehuchten was the first to announce the discovery of scattered sensory cells in the skin of the earthworm, though the observation was made some time earlier in the writer's laboratory. This author and Retzius agree that these cells are directly connected with the central nervous system by nerve fibres having origin in the cells. Such cells would seem to be analogous with sensory ganglia and might be supposed to combine the function of such ganglion cells with those of special sense cells (rod cells and the like).

Lewis Atheston has described (*Anat. Anz.*, xvi., 20) nervous structures in the worm *Tubifex rivulorum*, exhibiting a still higher differentiation. He shows that in worms there are not only scattered nerve cells in the epidermis which have the direct fibrous connection with the central system described by Retzius, but that there are other cells, in no way fundamentally different, which are grouped symmetrically to form sense organs upon the prostomium and first few segments of the body. These sense organs, though there are no specially modified supporting or central glandular cells as in vertebrates, bear an unmistakable resemblance to the lateral-line buds of amphibians, etc. Atheston finds all gradations between the isolated cell and the sense bud, and is inclined to regard the one as a derivative of the other, either in that the sense organ is the result of a closer aggregation of the isolated cells or that the isolated cells are the result of a degeneration of more primitive sense organs, perhaps as a result of the influence of the enclosing tube (see also Miss Langdon's paper on the "Sense Organs of Nereis." *Jour. of Comp. Neurol.*, x., 1.)

In the case of vertebrates the concentration proceeds further and the spinal ganglia are permanently separated from the skin, while the peripheral sensory fibres in most cases seem to arise in the cells of the ganglia and proceed by a process of repeated subdivision and elongation toward the skin, where connections are effected in a secondary manner with sensory cells in the epithelium.

In Amphioxus it would appear that the sensory ganglia are as yet unformed, their elements being scattered in the form of dispersed nerve cells throughout the dorsal or sensory nerve trunk in each segment. In lower vertebrates, notably aquatic amphibia, if our studies are correct, an intermediate condition is found. The peripheral sense organs show an unmistakable tendency to collect into bands along the lateral aspects of the body to form the so-called lateral-line organs which are composite aggregates of nervous and glandular elements. Not all the sensory cells are thus collected, but, especially on the head, there are numerous cells of unmistakably nervous nature that are not collected into buds as are those of the lateral line.

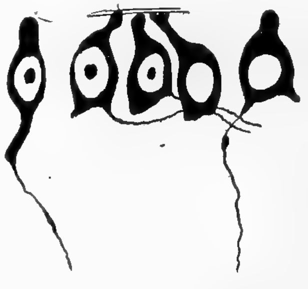

Fig. 1890. — Isolated Sensory Cells from *Tubifex rivulorum.* (After Atheston.)

In the tailless amphibia the curious fact was noticed that after the metamorphosis the sensory or rod cells are liberated from their original association in the "buds," and are scattered on the surface of the head and back in groups in such a way that the free or distal end of all the cells of the group lie in a pore of the skin. It seems scarcely to be doubted that these scattered groups are actually the same cells that in the larva are found in the sense buds.

The greatest diversity of opinion still prevails as to the nervous connections of these peculiar cells.*

The most probable view is that two entirely distinct sets of nerve fibres are associated with the lateral-line buds, one consisting of such a felting of perigemmal fibres as may be demonstrated by methylene blue in the case of skin glands, while in the other, the specific nervous structures consist of rod cells, not in the centre of the bud as stated by authors but more peripherally situated. The last-mentioned undoubtedly connect with a nerve fibre that seems to be continuous with the cell, though it is possible that there is an interruption of the actual continuity beneath the corium of the skin.

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* The contrast between the results of different methods is nowhere better illustrated than in the different conclusions reached by Fusari and Panasci on the one hand (Arch. italiennes de Biol., xiv., p. 240) and those of Arnstein (Archiv f. mikroskop. Anat., xxxi., 2). The former authors worked with the chrome-silver method and describe a direct communication of the nerve fibre with the rod cells of the taste buds. (This we are able to substantiate from personal observation.) Arnstein, on the other hand, denies such connection most emphatically and claims that teased preparations with methylene blue show with all possible clearness that there is no such connection, but instead that the varicose nerve fibres form a felting of fibres around the axial and outer cells of the bud and end free in the pore. Arnstein finds quite similar nerve endings in the filiform papillæ. He does not find forked cells, but inclines to the view that such cells result from the separation of the true nerve fibre from the peripheral end of the cell to which it is attached. The appearance of continuity between the cell and the nerve fibre is said to be illusory and is explained as due to the blackening of the cell as well as the fibre. Ehrlich (Deutsch. med. Wochenschrift, 1886, 4) described intensely colored cells in the mucous membrane of the olfactory region which pass without interruption into a nerve fibre, but these cases Arnstein also dismisses as illusory. Dr. Niemack has also reached similar conclusions by the use of different material (Anat. Hefte, Merkel und Bonnet, Anat. Anzeiger, viii., p. 20).

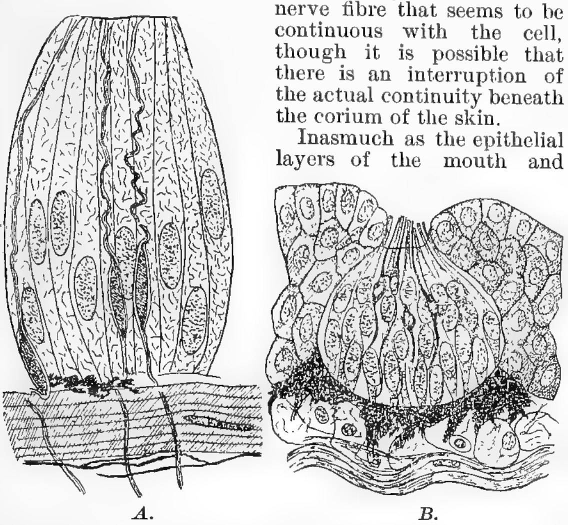

FIG. 1891 *A* AND *B*.—Sense Buds from the Skin of the Axolotl. (Original.)

Inasmuch as the epithelial layers of the mouth and tongue are morphologically only portions of the skin, it is necessary to examine these regions for light on the nerve endings as they may be modified under the special conditions here existing. In the frog, which has been the subject of the most elaborate investigation, the sense of taste cannot be at all highly developed, for the animal is accustomed to swallow its food, chiefly horny-coated insects, without mastication; and experiments (Bethe) prove a very sluggish response to chemical irritants. In the tongue of the frog, as well as in the palate, there are numerous scattered specific sense organs, those of the tongue being flat end-plates, while those of the palate are protuberant sensory papillæ. Although these organs were described by Leydig in 1858 they have frequently been the objects of special study since then, and even now authors are not wholly in agreement as to the details of the structure. The cellular elements in these sense organs consist of the cylinder of flask cells forming the protection for the sensory rod cells, a subordinate variety of which has been termed forked cells by reason of the divided peripheral projection. Alate, or winged cells, around the cup or flask have also been noticed by some authors. Bethe, who has recently studied these buds by means of the modification of the methylene-blue method which bears his name, finds two sorts of nervous termini in them: first, free termini lying between the cylinder cells and reaching the surface; second, termini with bulb-like expansions on various cells (Fig. 1894). One type of such endings is three-lobed and such endings are affixed to the sides of the cylinder cells; the other variety has simple circular end-plates and these endings are found on the rod cells, fork cells, and possibly also on cylinder cells. In no case did Bethe succeed in finding actual continuity between the rod cells and the nerve. He in fact seems to find greater intimacy of connection between the cylinder cells, which are not supposed to have a nervous function, than with the rod cells, and in no case is there more than a contact with the cell wall. He explains the continuity detected by Arnstein and others as the result of faulty observation and imperfect methods. In the ordinary pavement epithelium of the palate Bethe finds termini on gland cells and ciliated cells, as well as deeper elements.

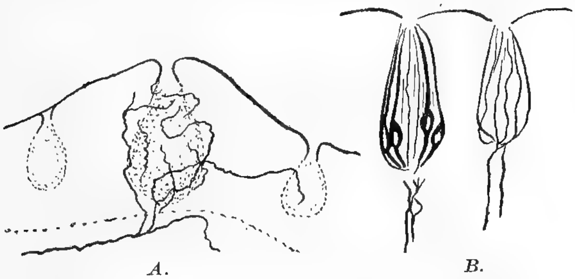

FIG. 1892.—*A*, Pericellular Endings from Sensory Bud of Conger Eel. *B*, Intrabulbar endings in barbus. (Lenhóssek.)

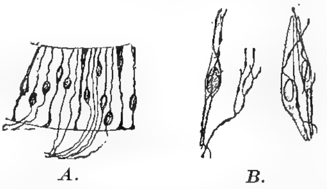

FIG. 1893.—*A*, Nerve Endings in Jacobson's Organ. (Lenhóssek.) *B*, Nerve endings in taste bulbs. (Arnstein.)

Our own studies of the gustatory epithelium of the axolotl are in accord with the results of Bethe upon the frog so far as the diffuse endings are concerned, though the methylene blue does not give adequate insight into the connections between fibres and cells. The taste buds, on the other hand, afford results similar to those obtained from the sensory buds of the skin. The source of many of the erroneous conclusions reached is, as mentioned beyond, the fact that in successful methylene-blue preparations it often happens that fibrous elements stain when the cells of origin for the same fibres do not.

Diffuse Peripheral Connections.—Various early writers have reported the existence of a dense network or felting of nervous material among the epithelial and even the corneum cells of the skin. This structure was first made out by the use of gold chloride, and there was always left open the possibility that the appearance was due to the disposition of metallic salts in the interstices between the cells. Dogiel, in his paper on the nerve endings of the genitalia, figures a very extensive meshwork of this kind with here and there a free knob-like termination, and he traces the lower part of the reticulum to a direct communication with a set of nerve fibres passing perpendicular to the skin (Fig. 1895). Strong, in his paper on the cranial nerves of the frog, figures a similarly minute meshwork. In all of the above cases there is the element of uncertainty growing out of the fact that the methods are impregnation rather than staining processes and are histologically uncertain. In the skin of the Amphibia there exists, at the base or ental aspect of the layer of Malpighi, a layer or stratum

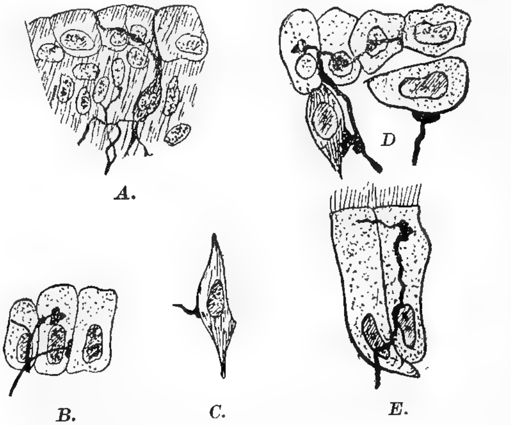

FIG. 1894.—Nerve Endings in the Epithelium of the Frog. (According to Bethe.) *A*, "Gabelzelle," from sensory papillæ of the tongue; *B*, cylinder cells; *C*, isolated rod cell; *D*, upper part of papilla; *E*, ciliate cell of palate.

which is in a peculiarly nascent state. These cells are devoid of the thick and rigid walls characteristic of the superficial cells and are protoblasts rather than complete cells. In this layer we may find, at all stages, the evidences of mitotic division. In fact there is a permanent proliferating zone in this region. Comparison of this stratum with that of higher vertebrates shows that the latter form no exception, though it is not always easy to detect the protoblastic elements. A single theoretical consideration is sufficient to convince one that this is what should be expected, for it is of course recognized that every type of vertebrate has some provision for the constant or occasional removal of the skin. In some cases the process of removal of the corneum is intermittent, while in others it is gradual. In either case it is obvious that there must be a proton of undifferentiated material—of cells that have not passed beyond the plastic stage. In those parts of the skin where there is little differentiation between the various layers the difference between the corneum and deeper cells is not readily detected in preparations by the usual processes, but in the thicker portions where the so-called Leydig cells appear the basal protoblasts are crowded into the interspaces and pried apart. One effect of this process has been to stretch the connecting protoplasm into an excessively thin layer or film enveloping the Leydig cell either completely or as a coarse meshwork of naked protoplasm. In all the preparations we have seen, the appearance is that of a broad reticulum arising in the intercalary or basal protoblasts and enveloping the cell in such a way as to wrap it completely in the products of the adjacent protoblasts.

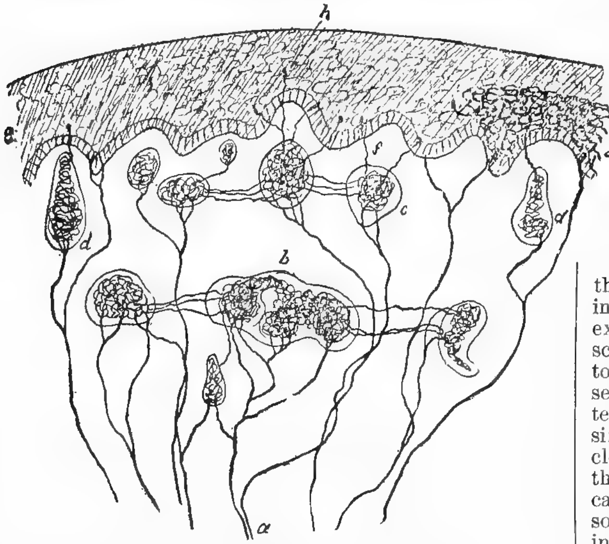

FIG. 1895.—Diagram of the Skin of the Sexual Organs. (After Dogiel.)

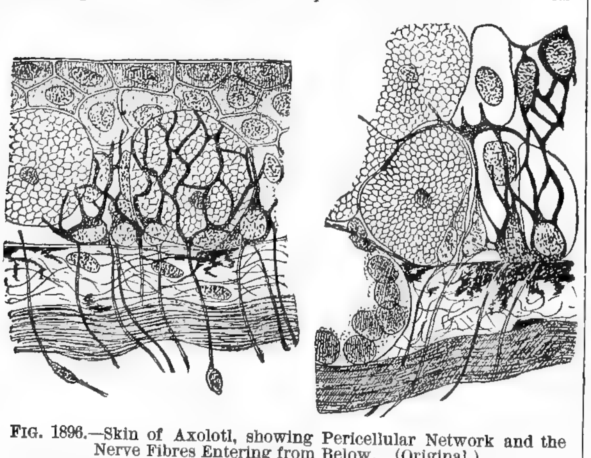

FIG. 1896.—Skin of Axolotl, showing Pericellular Network and the Nerve Fibres Entering from Below. (Original.)

The nerve supply to the reticulum is abundant, and the fibres can be traced without difficulty through the corium layer in all preparations. The sheaths seem to cease after passing the corium and the subsequent course is less easy to make out. In a considerable number of cases it has been possible to trace such fibres with all desirable clearness to actual connection with the bases of the lower protoblasts above-mentioned. The fibre is red, as is the protoplasm, so that it remains possible that the exact nature of the union is not obvious, yet from the fact that two masses of naked protoplasm thus come in contact, the range for possible modes of union cannot be extensive. It is believed that the condition above described in so striking an example is by no means limited to the aquatic or semi-aquatic vertebrates. It has simply been most clearly seen in these cases because the cells are so large and the intracellular reticulum is so evident (Fig. 1896). It is evident that many of the endings to be described beyond as free nerve endings receive a new interpretation when it is understood that these may be in immediate contact with protoplasmic material lying between the mature cells and forming a stroma in which they are in a sense embedded. It has been suggested that to some such reticulum as that indicated the organs may owe the remarkable solidarity and co-ordination of their activities.

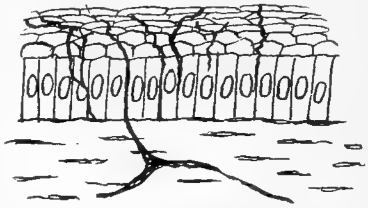

FIG. 1897.—Vertical Section through the Outer Part of the Cornea of a Rabbit. (After Kölliker.)

Free Nerve Endings of the Skin.—It seems abundantly proven, in spite of the doubts of Krause, Goldscheider, and others, that free nerve endings exist in the epidermal layer of the skin. These are among the most difficult objects to prepare suitably for study and, as suggested above, it is probable that these fibres have relations primarily with an intercellular reticulum derived from protoblasts of the Malpighian layer. The cornea is a favorite part of the skin in which to demonstrate these fibres, but they seem to be distributed over the whole body surface.

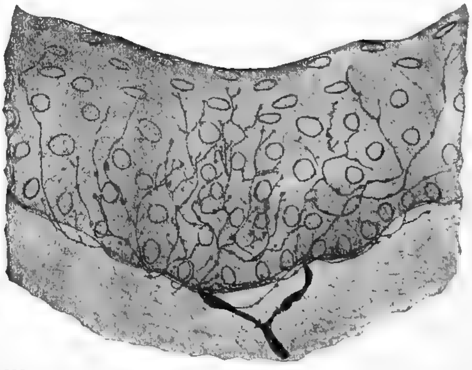

FIG. 1898.—Section through Epithelium and Part of the Mucosa of the Œsophagus of a Cat. End-ball with terminal arborizations.

Belonging to the same category apparently are the so-called tactile menisques identified by Ranvier. In this case also the fibres communicate with ill-defined flattened intercellular bodies in the superficial and deep layers of the skin.

It is as yet impossible to determine what the relation of the fine arborizations of these free endings may be to the so-called hot and cold spots. It appears, however, that the perception of heat and pain is intimately associated with circulatory changes and that the nerve supply to the capillaries must not be overlooked.

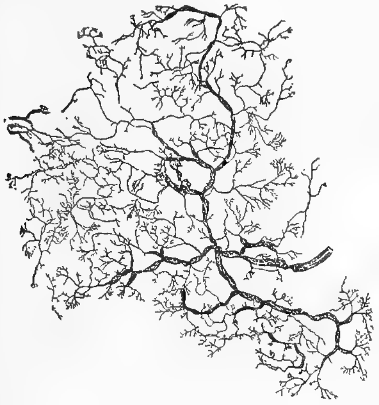

FIG. 1899.—Tangential Section of Mucosa of Œsophagus of Cat.

Miss DeWitt has described with much skill the terminations of free fibres in the mucous membrane of the œsophagus.

"The large, medullated, sensory fibres, found in the nerve trunks of both the intermuscular and the submucous plexus, pass through the muscularis mucosæ and form, with frequent branching, a finer-meshed plexus in the deeper parts of the mucosa. From this plexus branches, still medullated, are given off, which pass, repeatedly dividing at the nodes of Ranvier, toward the epithelium. Under the epithelium, these nerve fibres lose their medullary sheaths and form a fine-meshed subepithelial plexus, whose fibres extend for considerable distances under the epithelium. Before losing their medullary sheaths, many of the medullated fibres give off at the nodes of Ranvier non-medullated fibres, which also pass up toward the epithelium and assist in the formation of the subepithelial plexus. From this plexus, as well as from non-medullated fibres which come up directly from the mucosa and seem to take no part in the formation of the plexus, fine, varicose nerves pass up into the epithelium, wind between the epithelial cells, occasionally giving off longer or shorter branches, which terminate in varicosities of different forms and sizes; the terminal fibres also finally end in ball-like thickenings on or between the epithelial cells, either near the surface or at a greater depth.

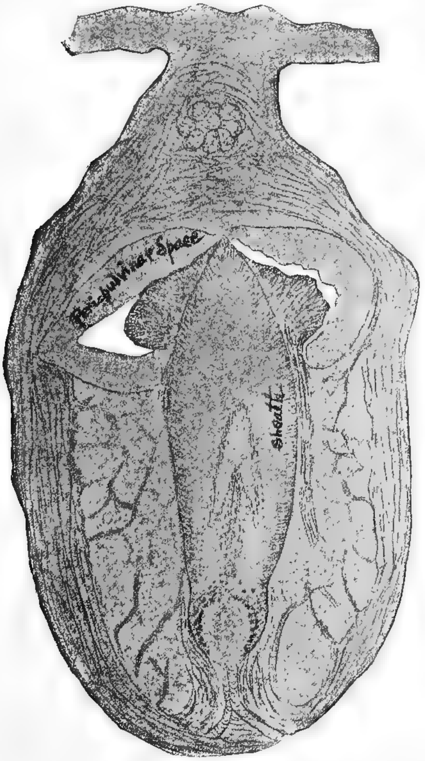

FIG. 1900.—Longitudinal Section of Vibrissa, showing the Pulvinus or Erectile Organ and the Path of the Nerve to the Annular Ring.

"That the terminal and lateral arborizations surround the epithelial cells, ending on or between the cells in small varicose thickenings, sometimes on the surface cells and sometimes on the deeper ones, may be seen in Fig. 1898, taken from a cross section of the œsophageal mucosa of a young cat. In the greater part of the œsophagus, these terminal arborizations seem to be puite evenly distributed, and it has seemed to me probable that nearly all of the epithelial cells come in contact with one or more of the terminal nerve fibres. In the upper part of the œsophagus, however, near its junction with the pharynx, there are, in addition to these uniformly distributed telodendria, certain peculiar ball-like masses, consisting of the telodendria of several nerve fibres, whose branches are very short and soon become non-medullated. The non-medullated fibres soon break up into long, slender, varicose end-branches, forming end-brushes which meet and intermingle with the end-brushes of other nerve fibres, making a dense and compact mass of terminal nerve fibres, which, on superficial examination, resembles a special sensory end-organ. Closer study, however, fails to reveal the presence of a connective-tissue capsule, and, in cross sections, we find that the ending is in the epithelium and does not differ from the end-arborizations in other parts of the mucosa except for the fact that here they are more closely crowded together, more richly branched and beset with larger and more abundant varicosities."

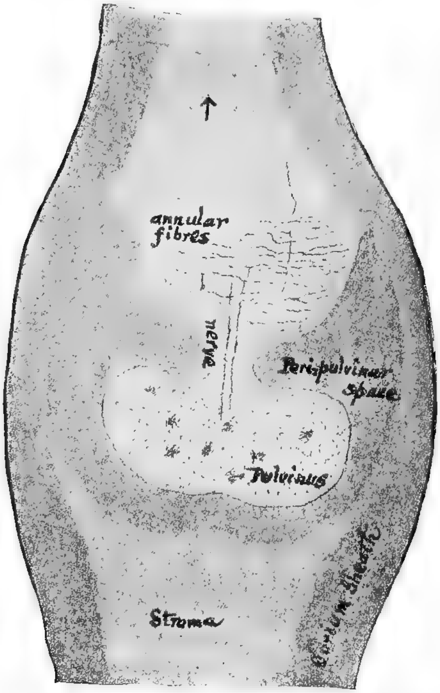

FIG. 1901.—Longitudinal Section of Sheath of Vibrissa at the Pulvinus, showing Part of Annular Nerve Ring as seen by Golgi Method. (From Messinger, after Herrick.)

A modification of the free endings is found in connection with certain modified hairs. The vibrissæ of carnivoræ, for example, have a curious hæmostatic or erectile apparatus in connection with the hair bulb, and around the neck of the bottle-shaped bulb is an annular arrangement of fibres that seems to be intended to serve as a means of receiving tactile impressions arising from movements of the hair.

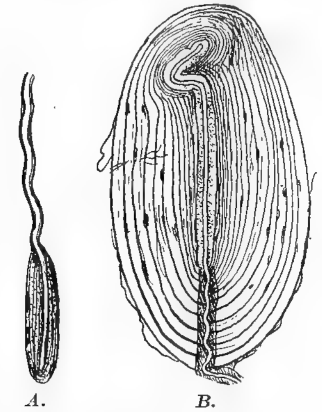

FIG. 1902.—*A*, Krause's End-Bulb. *B*, Pacini's body.

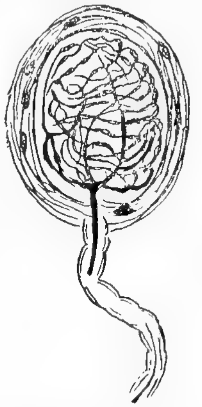

FIG. 1903.—Nerve Ending in Human Conjunctiva. (Dogiel.)

Terminal Corpuscles.—These differ from the free termini in the fact that the nerve ending is surrounded by a more or less complicated sheath of connective tissue, and it would appear as though the arrangement of parts was destined to apply external pressure or irritation more directly or powerfully to the nerve fibre.

The nerve bulbs of Krause are the simplest of these organs and are found in the conjunctiva, lips, tongue, and genitalia. They consist simply of a sac of connective tissue of round or oval form in which the end-fibre lies either as an axial thread or as a complicated coil. In the case of the genital corpuscles there seems to be, according to Dogiel, a complicated lateral anastomosis between the fibres of the different corpuscles affording an opportunity for excessive irradiation of the stimulus.

Tactile corpuscles proper are much more complicated structures. The neurilemma of the entering nerve fibre becomes continuous with the sheath of the corpuscle. Each corpuscle may receive from one to four fibres which enter with their sheaths for some distance. The fibre then becomes non-medullated and forms numerous coils or loops within the corpuscle. These corpuscles are especially numerous on the palms and soles, on the margins of the lips and in the genitalia, but are not confined to these organs.

Pacini's corpuscles, which are most numerous in the joints and in the mesentery, though also found in the corium layer of the skin of the extremities, have something in common with the end-bulbs, being quite simple in structure, with a single straight or slightly curved axial nerve fibre. The simple bulb is, however, clothed with numerous concentric capsules and the whole covered with a connective-tissue pseudo-epithelium of polygonal cells.

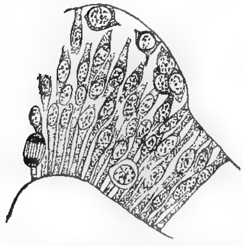

FIG. 1904. An Early Stage in the Olfactory Epithelium. Neuroblasts proliferating and migrating to inner aspect of epithelium.

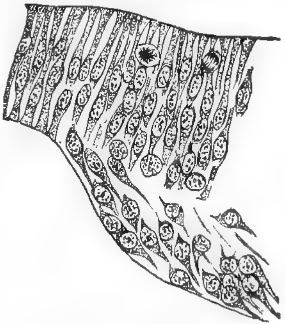

FIG. 1905.—A Later Stage of Olfactory Epithelium. Beginnings of olfactory nerve.

Organs of Special Sense.—It is generally believed that the sensory elements in the organs of higher sense have been derived from the simple form of rod cell found in the lateral-line buds and taste buds. The latter have already been referred to as being obviously similar to the lateral-line organs, and we believe that whatever method of nerve connection shall be determined in one will also be found characteristic of the other, unless, indeed, the nervous connections in one or the other case prove to be secondary, as is not impossible. From a speculative point of view it is impossible to say whether the gustatory cells are derived from parts of the lateral sensory bands arising between the pituitary and the olfactory or whether they have entered the mouth in a secondary way viâ the gill clefts.

For both the olfactory and Jacobson's organ the direct connection of the specific cell with the nerve fibre has been demonstrated.* In these cases most writers agree also that the radix fibres are the product of moniliform series of neurocytes or neuroblasts. The writer is much inclined to regard this as the primitive method of nerve formation and one that prevails in the case of other peripheral nerves in a disguised form.

The first indication of the change of the ordinary to the sensory epithelium is seen in the thickening of a portion of the superficial layer from the morphological front of the head (the region of the future infundibular recess) in relatively broad bands, one on either side of the head. As the head flexures increase, these areas are carried ventrad and come to occupy the roof of the mouth and adjacent parts of the buccal cavity. The development of the taste buds from this epithelium we have not traced in these subjects, though it is probable that they are formed from this proton, as the mucous parts of the hypophysis are. At the time the first olfactory rudiments appear, the curvature is such that the hemispheres are protuberant in front and so come nearly in contact with the prota of the olfactory in the two bands of germinative epithelium above mentioned. Still there is no difficulty in seeing that the original proliferations take place in the skin, and that the constant proliferation by division of the earlier cells spins the nerve fibre from the original

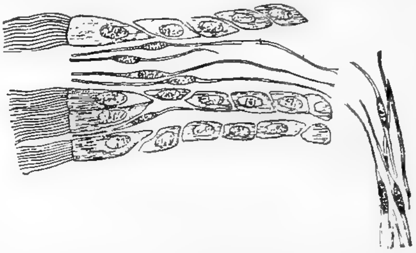

FIG. 1906.—Teased Preparation for Olfactory Epithelium of Salamander.

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* Although there was for a long time considerable disagreement as to the actual connections of the olfactory nerve fibres, and the classical studies of Kölliker, Klein, and Piana left the matter open, it seems as though the later studies of Ehrlich, Arnstein, Cajal, Gehuchten, Retzius, Brunn, and Lenhossék, who employed the silver and methylene-blue methods, were sufficient to prove conclusively that the olfactory epithelium possesses rod cells whose proximal end is in actual continuity with the fibre of an olfactory nerve filament. The writer has frequently verified this in specimens of Amphibia double-stained with hæmatoxylin and picrocarmine, in which very unambiguous views can be secured. A few figures from these preparations were published by Mr. Bawden, then a student in the writer's laboratory (Jour. Comp. Neurol., iv.). Our studies in the development of the olfactory nerve show that the proton of the nerve is formed in or under the epithelium of the nasal area, and that the nerve grows by moniliform concrescence of cells which arise by mitosis from this proton. From this standpoint, then, it would be expected that the neurocytes of origin would be found in the epithelium. In all essential respects the relations in Jacobson's organ are the same as in the true nasal olfactory epithelium.

source to the point where the tuber subsequently arises. In fact, the tuber, which has frequently been compared to the ganglion of origin of a cranial nerve, does not seem to afford origin for any centrifugal fibres whatever. In preparations by the silver method it is easy to see that the neurite of the moniliform chain of the olfactory nerve comes into relations in the glomerules with dendrites of the mitral cells.

For a long time during the development of the brain an obvious ganglionic mass lies below the skin at the base of the point of origin of the olfactory. The gradual elaboration of the cavities of the nares only serves to redistribute the prota without materially disturbing the simplicity of the arrangement.

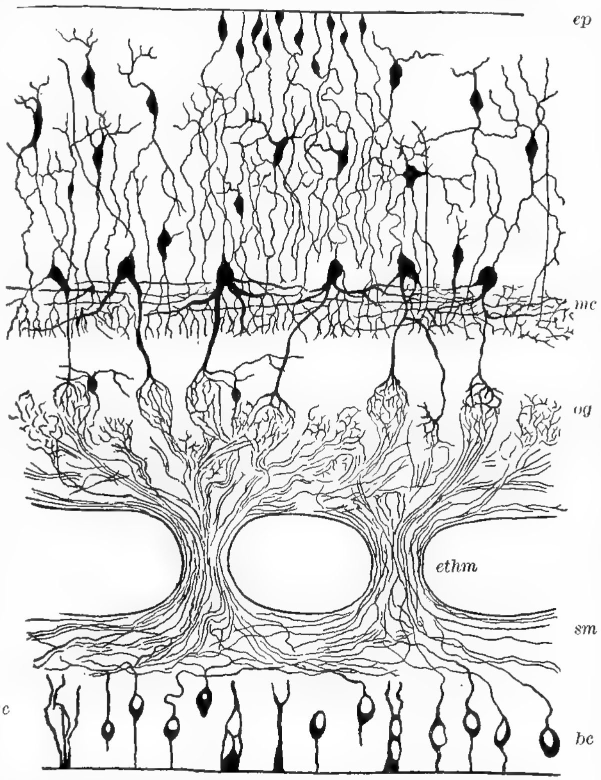

FIG. 1907.—Structure of the Olfactory Filaments and Bulb. (Ramón y Cajal.) *bc*, Bipolar cells of the olfactory mucous membrane; *sm*, submucosa; *ethm*, cribriform plate of the ethmoid; *og*, olfactory glomeruli; *mc*, mitral cells; *ep*, epithelium of the olfactory ventricle; *ec*, epithelial cells of the olfactory membrane.

The fact that the lens is essentially a sensory depression, homologous with the nasal sac, is one of the well-established generalizations of the last few years. In this case, however, neuroblasts are not developed, and the spongioblasts undergo very remarkable gelatinous transformation, though the nuclei may always be demonstrated by sufficient preparation.

The internal ear is the next organ of this lateral series, and its formation beautifully illustrates the uniformity in diversity characteristic of all morphological processes. The auditory sense organ, like the preceding, is an invagination of specialized sensory epithelium continuous with that which, in lower vertebrates, forms the "organs of the lateral line." It first appears as a saucer-like depression (Fig. 1908), from which is formed the capsule from the various transformations of which the "membranous labyrinth" with its sensory patches is formed.

The primitive sac divides into a cephalic and a caudal portion. Comparison of the methods of development of the lateral-line organs in the dogfish, for example (Ayers), shows great similarity with the early morphological changes in the ear by which the semicircular canals are formed. "Within the two chambers formed four canal sense organs develop. The two external organs are soon enclosed within the ampulla of the two complete and relatively large canals which are now formed about them." "Up to this time the organs have retained the primitive relations to each other, a serial arrangement along a line running in an antero-posterior direction. Now there begins a distortion of the structure as a whole, which continues ever after and reaches its greatest development in the mammals, viz., a process of sinking and drawing out ventrally of the posterior chamber of the ear, so that hereafter we might speak of a superior and an inferior portion or chamber" (Ayers). By progressive subdivisions the four patches give rise to the eight definitive auditory sensory organs of mammals. Meanwhile, the neuroblasts have migrated to the ectal surface and give rise to the two ganglia (vestibuli and cochleæ) from which the two branches of the auditory nerve are produced.

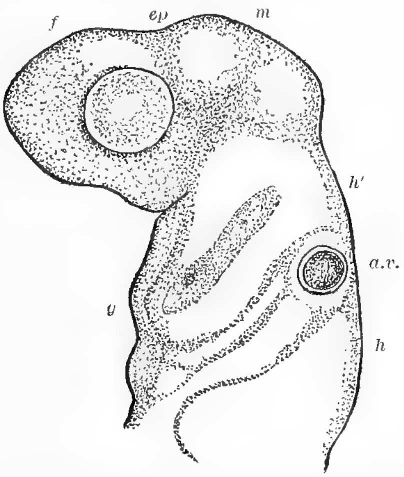

FIG. 1908.—Head of Embryonic Shark, *Acanthias vulgaris*, showing the saucer-like depression, corresponding to the insinking sense organ which is to be converted into the auditory sense organs of the shark. *a.v.*, Auditory vesicle; *ep*, position of epiphysis; *m*, mesencephalon; *f*, fore-brain; *g*, gill region; *h*, medulla. (After Ayers.)

The transformations of the epithelium in the formation of the organ of Corti are out of place here, but obey laws easily intelligible from our knowledge of the history of the spongioblasts elsewhere.

The retina is essentially a modification of a portion of the primitive neural tube. The pigment layer undergoes a change directly comparable with that which produces the velum cerebelli or the introductory stages of plexus formation. The original limits of the tube are represented in the retina by the membranæ limitantes.

The relations are at first exactly as in the brain proper (Fig. 1909). The neuroblasts are

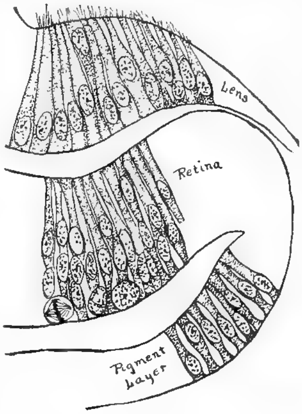

FIG. 1909.

formed adjacent to the ventricular surface and migrate to the ectal surface. A portion remains in the nuclear (granular) layers and corresponds to the granules which lie adjacent to the ventricles in the brain. The method of formation of the rods and cones is still a matter of dispute. Professor His thinks they are formed by protrusion of backward-growing processes of the neuroblasts. It is, perhaps, doubtful if we have not to do with the nuclei of the spongioblasts and the greatly modified homologues of the cilia characteristic of ventricular epithelium. In any case the true neurons collect in a single or double series on the vitreous surface of the retina, and give rise to an axis-cylinder process which passes through the chiasm to the tectum opticum, and to protoplasmic processes which subdivide in the "inner molecular layer" (equivalent to the marginal reticular zone of the brain). The direct connection between the ganglion cells and the rods and cones has not been observed, and probably the connection is through a reticulum or neuropilem as in all other cases. The nerve fibres develop in the human retina at about the fifth week. It is obvious, from the results of recent investigation, that fibres arising in the tectum opticum pass toward the retina as well as vice versa.

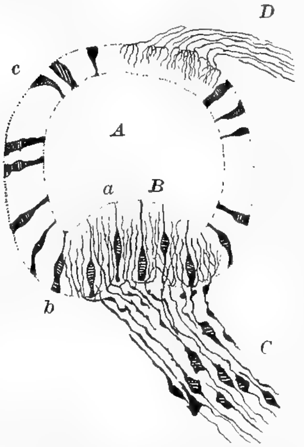

FIG. 1910.—Collecting Filaments of the Vestibular Branch of the Auditory Nerve. (Ramón y Cajal.) Transverse section of the semicircular canal of a mouse. *A*, Lumen of the canal; *B*, acoustic crest; *C*, bundle of nerve fibres containing bipolar cells; *D*, a similar bundle supplying the top of the canal; *a*, *b*, and *c*, varieties of bipolar epithelial cells.

Further discussion of the organs of special sense is rendered unnecessary by the fact that vision and audition are fully treated under these heads.

Muscle Spindles are problematical nervous organs which are supposed to supply the sensory stimuli on which are based the muscular sense and pressure sense. They were first described by Kölliker but were first proven to be sensory by Sherrington. The most complete account is that of Huber and DeWitt (*Journ. Comp. Neurol.*, vii., 3, 4) from which the following is taken.

"The capsule or perimysial sheath, has essentially the same structure in all vertebrates examined, although it varies much in thickness. It is made up of concentrically arranged layers of white fibrous tissue, the several layers being often in close apposition, or again more or less distinctly separated one from the other, leaving larger or smaller clefts between them. The number of these concentric layers varies; Sherrington places it at six to eight, which number holds good for many of the muscle spindles seen by us, especially those found in mammalian muscle. The fibrous tissue of the concentric lamellæ is white fibrous, practically devoid of yellow elastic tissue. At the beginning of the muscle spindle (proximal end), the capsule becomes continuous with a somewhat thickened perimysial sheath, which surrounds the muscle fibres about to enter the muscle spindle. The behavior of the capsule at the distal end of the muscle spindle depends somewhat on its relative position in the muscle. The spindle may be embedded in the muscle substance, in which case, as Sherrington correctly states, 'its long axis lies parallel to the muscle fibres amid which it is embedded'; here the distal end of the capsule seems again to become continuous with the internal perimysium.

"More immediately surrounding the enclosed muscle fibres, designated by Sherrington as '*intrafusal fibres*,' there is found a connective-tissue sheath which he has described as the '*axial sheath*,' consisting of thin bands or plates of white fibrous tissue in which nuclei are numerous.

"Between the capsule and the axial sheath is found a relatively large lymph space—Golgi and Sherrington—designated by the latter as the '*periaxial space*'; this, he correctly states, is 'bridged across and partially subdivided in many points by extremely tenuous membranes and filaments.' The periaxial lymph space is broadest near the middle of the muscle spindle, generally tapering off toward the ends. The intrafusal fibres are sometimes in the middle of this space and again eccentric. The space also shows buddings here and there, which seem, however, in a large measure due to foldings in the capsule, the result of contraction of the contiguous muscle fibres."

From one to four large medullated nerves end in the smaller spindles and from five to eight in the larger, compound spindles.

Single spindle nerves are surrounded by a thick sheath of Henle; small bundles of spindle nerves, by a connective-tissue sheath, which becomes in part continuous with the capsule, in part with the axial sheath. The spindle nerves remain medullated until they are within the axial sheath, the internodal segments becoming shorter as the muscle spindle is approached; but this is more especially noticeable after they have penetrated the capsule. After losing the medullary sheath (within the axial sheath), the non-medullated continuation of spindle nerves undergoes further subdivision, before the ultimate ending is reached.

Ruffini, whose account we may here follow, describes, for the cat, three types of ultimate endings of the spindle nerves—spiral, circular, and flower-like endings ("terminaisons à spirales. à anneaux, et à fleurs"). Of these, the spiral endings may be first considered, as they seem to us the most typical. The non-medullated terminal branch of the spindle nerve thus ending, flattens out into a ribbon-like ending, more or less irregular, which is spirally wound around the intrafusal fibre, this spiral extending for a longer or shorter distance along the intrafusal fibre; the spiral turns are sometimes so close together that they almost touch each other, or again, farther apart, so that they can be clearly made out. These spirals have also been described by Kerschner, who very correctly adds that from place to place offshoots proceed from the spiral, which may end on the intrafusal fibre surrounded by the spiral, or on some contiguous intrafusal fibre. The "ring-shaped" endings of Ruffini have, we believe, been correctly interpreted by Kerschner as lateral views of flat spirals. Such ring-shaped endings may, however, now and then be formed by short side branches of the non-medullated terminal branches, which almost completely, or completely, encircle an intrafusal fibre; several such endings may be side by side on an intrafusal fibre. The flower-like endings mentioned by Ruffini, are, no doubt, as suggested by Kerschner, the terminal endings

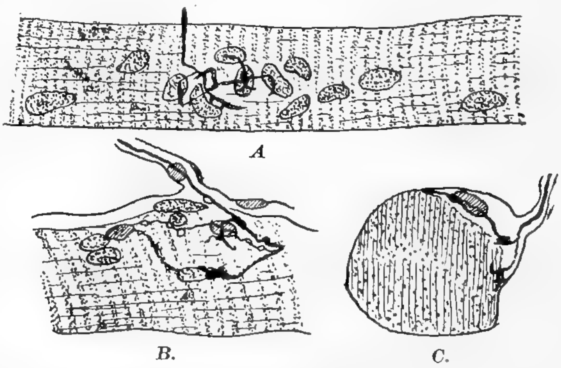

FIG. 1911.—*A* and *B*, Motor Plates from Muscle of Rabbit; *C*, cross section of muscle and motor plate of Frog. (After Huber and DeWitt.)

of the spirals, or of branches from the spirals; they may, however, now and then be seen as branches from the terminal, non-medullated continuation of the spindle nerves, which have a zigzag course on an intrafusal fibre without forming a spiral.

Batten shows that "in infantile paralysis the spindle remains absolutely normal, although the surrounding tissue undergoes complete atrophy. In tabes, he shows that certain changes take place in the termination of the nerve, the general structure of the spindle remaining normal. In progressive muscular atrophy the spindle remains unaltered, and the same is probably true with regard to peripheral neurites. Section or atrophy of the nerve trunk leads to atrophy of the muscle fibres within the spindle, though it is probable that it takes a considerable length of time for changes to take place in the muscle fibre within the spindle."

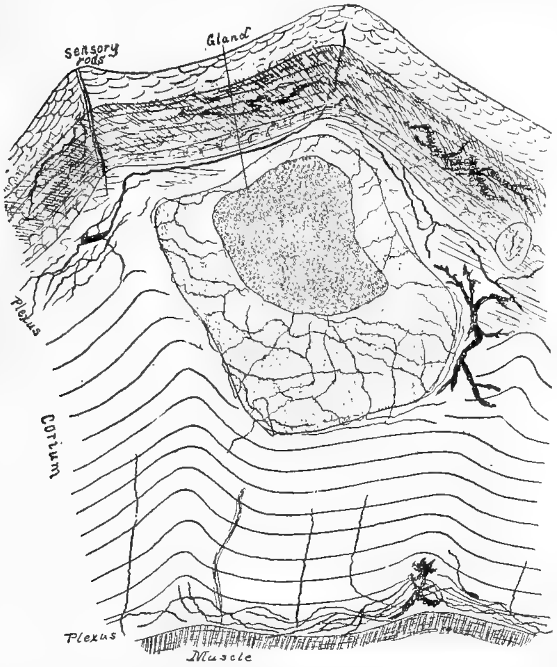

FIG. 1912.—Section of the Skin of the Head of a Toad (Bufo) after *intra-vitam* injection with methylene blue and fixation with Bethe's solution of molybdate of ammonia. Examined in glycerin. The section is somewhat oblique so that the duct and part of the body of the gland are absent. The delicate non-medullated fibres are seen generously distributed over the uncut surface of the gland. Coarser fibres are also seen in the lower and upper plexuses, also a bundle of sensory rods at the left.

KINESODIC END-ORGANS.—The most important termini of the centrifugal system are those upon muscles and glands. The motor end-plates are the points of attachment of the motor nerve fibres upon the muscles and are accordingly the receiving stations of the muscle and the points whence the stimulus is distributed to the fibre prior to its contraction. They were first observed by Doyère in 1840 and have been the subjects of much patient investigation since that time. The best work in this field is that of Kuehne, which has been ably supplemented by Huber and DeWitt. The fibre penetrates the sarcolemma and forms a very complicated arborescent figure by the ramifications of the axis cylinder, and this may be regarded as the end-brush of one or more motor neurites. The granular mass in which the nerve fibre terminates was at first supposed to be an expanded portion of the nerve fibre. It contains nuclei (the sole nuclei) which have been variously interpreted. The following summary from Huber probably expresses the present state of our knowledge:

"(1) The ramified terminations of the axis cylinder in the motorial endings of striped muscle are the end-brushes of the neuraxes of motor neurons, and are similar in structure to the end-brushes of other cerebro-spinal fibres.

"(2) This end-brush (*das Geweih*, Kühne) terminates in the sarcoplasma, therefore under the sarcolemma of the muscle fibres. At the place of ending of the nerve fibres, the sarcoplasma may be accumulated in a circumscribed mass, forming an elevation, more or less distinct, on the side of the muscle fibre, as in reptilia, birds, and mammalia, or spread out over a proportionately greater area of the muscle fibre, as in amphibia. In the mass of sarcoplasma, the muscle nuclei (sole nuclei of other writers) are relatively more numerous than in other parts of the muscle fibre.

"(3) The neurolemma of the nerve fibre terminating in the motorial ending becomes continuous with the sarcolemma at the point of entrance of the said nerve fibre into the sarcoplasma. Over the endings, sarcolemma or neurolemma nuclei—telolemma nuclei—are seen.

"(4) The neuraxis of the motor neuron loses its medullary sheath before piercing the sarcolemma."

With reference to the endings in glands and other visceral organs space need not be taken here as the discussion will naturally accompany the articles on these organs. The drawing in Fig. 1912 will sufficiently illustrate the complexity of the nerve supply to glands and the difference between these endings and those of a sensory nature.

C. L. Herrick.

ENDOTHELIOMA. See *Sarcoma.*

ENDOTHELIUM. See *Epithelium.*

ENEMATA. See *Enteroclysis* and *Alimentation, Rectal.*

ENGADINE (UPPER), SWITZERLAND.—The Upper Engadine valley extends from Maloja, at the summit of the pass, to a little beyond Samaden, in a direction from southwest to northeast. Through this valley runs the Inn, while high mountains belonging to the Bernina and Julier chains enclose it on either side. The Upper Engadine valley is wider than the lower and contains several lakes. It is about thirty miles in length, and varies from a half a mile to a mile in width; and its mean height above sea level is 5,500 feet. The whole Engadine is one of the highest inhabited valleys in Europe. In the Upper Engadine are situated the health resorts of Maloja, St. Moritz, and Samaden, where consumptives go in the winter for the "air cure"; and Pontresina and others which are visited in the summer only.

The Upper Engadine valley is again divided into an upper and a lower portion, quite different in the character of their scenery. In the upper portion, extending from Maloja to St. Moritz, where are situated the lakes beforementioned, the mountain boundaries on either side are grander and wilder and much loftier, and their summits are covered with extensive glaciers and snow fields. In the lower half, extending from St. Moritz to the termination of the valley, the picture is quite different. "Here there are no lakes, the floor of the valley is much wider, and is occupied by broad stretches of meadow-land through which the Inn quietly and tamely flows along." "The mountains on each side are of lower elevation; they all rise in gentle slopes from the floor of the valley, and present no bold or striking features of form or outline."

The upper or southern end of the valley is open and affords a ready ingress to storms of wind and rain approaching the valley from the southwest; the wind, however, blows most in spring and summer, while the winter is the calmest season of the year.

Climate.—The climate of the Upper Engadine is very similar to that of the neighboring valley of Davos, already described. (Cf. *Davos.*) In the first place, there is the striking variability of the temperature as in all high-lying stations. The diurnal variations are sudden and great; for instance, in August, between seven and ten o'clock, the mercury rises from 44.6° to 53.6° F.; and again at sunset it falls as rapidly as in the morning it rose. Secondly, the great radiant heat of the sun is another characteristic; for instance, the maximum sun temperature in the upper Engadine on February 4th, 1876, was 118° F.

The number of hours of possible sunshine in winter is somewhat greater in the Engadine than at Davos; for example, on January 1st, the sun rises at Maloja at 9:35 and sets at 3:45, while at Davos it rises at 10:03 and sets at 3.

The average rainfall, most of it being snow, is 32.67 inches; it lies on the ground for over five months, beginning about November 14th. The relative humidity is 75 per cent. The mean annual temperature is about 36.5° F., and for the seasons as follows: Winter, 18.1° F.; spring, 33.7° F.; summer, 50.9° F.; autumn, 36.5° F. There is said to be rather more cloudiness in the Upper Engadine than at Davos. As at Davos, the purity and exhilarating quality of the air in this region constitute, in brief, the great striking characteristic which all experience who enter this valley. The writer can never forget his own sensations as he came over the pass from Chiavenna into this delicious atmosphere. Merely to exist was a delight, and to spend the day in tramping over a glacier or mountain climbing was exquisite pleasure, and after such exertions no sign of weariness was experienced.

A considerable number of consumptives take the winter cure here, and there are excellent accommodations at Samaden, St. Moritz, and Maloja; at the latter is the large Kurhaus, accommodating five hundred guests and especially arranged for a winter residence; the ventilation and sanitary arrangements are of the best. In the village of St. Moritz is the great caravansary "Engadiner Kulm," with a wonderful view over the whole district of St. Moritz. Here one can find every comfort, and even luxury,—large reception-rooms, a library, a dining-room for three hundred and fifty persons, and a fine collection of engravings and pictures. The English and Americans chiefly patronize this hotel. St. Moritz is the highest village in the Engadine or in Switzerland, having an elevation of 6,085 feet.

A mile or two from St. Moritz village are the St. Moritz baths. These are supplied from two acidulous iron springs,—the old and the new, containing soda with a large proportion of fixed solids and free carbonic acid. These waters are used both for drinking and for baths and are visited in the season—from the middle of June to the middle of September—by numerous patients of all nations. The conditions benefited by these waters are anæmia, chlorosis, dyspepsia, menstrual irregularities, various derangements of the nervous system, etc. There is a large Kurhaus with many rooms, two bath houses containing eighty baths, and complete hydrotherapeutic arrangements (warm, cold and Scotch douches, sitz baths, vapor baths, etc.), as well as facilities for massage. There is a covered promenade leading from the Kurhaus to the spacious pump room of the new spring. There are generally about three hundred and eighty patients in the Kurhaus, and every attention is given to their comfort and diversion.

What has been said regarding the winter climate of Davos in the treatment of pulmonary tuberculosis applies equally to that of the Engadine; there is no material difference between the "air cure" of the Davos and that of the Engadine valley, and the results should closely resemble each other. In the winter resorts of the Upper Engadine there is greater variety of scenery and the life is more restful and quieter.

Regarding the uses of such a climate as that of the Upper Engadine for cases other than tuberculosis, a few words can properly be said here, applicable also, in a measure, to all high-altitude resorts. Whatever the malady or condition there should exist a "certain integrity and reactionary power of the constitution," if the patient is to be benefited by a climate which is stimulating and bracing, such as this. This being presupposed, we can say, in general, that where functional activity needs to be improved, and the whole system toned up, a few weeks' residence in this pure, clear, dry, bracing air will almost surely produce favorable results. "I believe," says Burney Yeo, "this kind of climate is especially useful to those who have been *strong*, but by some accident or other, such as overwork, or illness, or trouble, have become weak; to those who possess a latent power of reaction." To enumerate especial conditions, there may be mentioned, nervous dyspepsia, want of appetite, sleeplessness, malaria, neuralgia, anæmia, the later stages of convalescence from severe illness, hypochondriasis, asthma uncomplicated with emphysema or organic disease of the heart or arteries, chronic bronchitis with much secretion, and those various mal-conditions arising from "insufficient exercise in the open air and deficient absorption of oxygen."

Burney Yeo happily expresses it when he says that much of the benefit that is derived from a short residence in an elevated region like that of the Upper Engadine is due to the alterative influence which it exercises on the human organism. "In passing," he continues, "from the sea-level to an elevation of over 6,000 feet we must alter in a very essential manner the conditions of our lives."

It is well also to bear in mind some of the contra-indications of a mountain climate like this. Such are, weakness from extremes in age; constitutional weakness; organic cardiac disease; atheroma; chronic bronchitis with dilated bronchi; and emphysema, muscular debility and general exhaustion, rheumatism and inability to endure great and sudden changes of temperature.

Finally, if we are not in search of health or better health, we all need change occasionally,—"that change which is the type of life and the condition of health; that change which is rest." Where can a more complete or a more refreshing change be found than among the grand glaciers and majestic mountain peaks of the Upper Engadine, where we can "draw in easier breath from larger air." *Edward O. Otis.*

ENTERITIS.—An inflammation of the small intestine, involving particularly the mucous membrane, and to a less extent the submucous layer. It may be either acute or chronic. The whole length of the intestine may be involved or, more usually, the inflammation is limited to certain portions of this.

The meaning of the term *enteritis* has varied considerably as used by different authors, and at different periods in medical literature. It does not appear to have been in use by the ancients. In the eighteenth century it was applied to the group of symptoms now included under peritonitis, although Cullen (1784) mentions two varieties of the disease, one of which evidently refers to an inflammation of the mucous membrane and subjacent tissues of the intestine. In France, at about the end of the eighteenth century, Pinel limited the use of the word to an inflammation of the intestinal mucous membrane. Its meaning was further restricted during the first half of the nineteenth century by Broussais (1821), who applied it to an inflammation of the mucous membrane of the small intestine only, and gave the name colitis to a similar process in the colon. This restricted meaning has been more or less generally retained up to the present time.

At the beginning of the last century the lesions of the intestinal lymphoid structures found in typhoid fever were included under the general term enteritis, and this use of the term was continued to some extent even after the specific nature of the lesions had been demonstrated. At present the term is avoided by some authors, "intestinal catarrh" being used instead as indicating the character of the most frequent form of inflammation of both the large and the small intestines. While it is recognized that the same etiological factors may produce similar changes in either the large or the small bowel, that usually each is involved to a greater or less extent in both the acute and the chronic catarrhs of the intestine, and that at times it is difficult to determine the exact parts involved, yet, as the symptoms referable to the one or other part of the intestine vary to some extent, and as the treatment must necessarily differ accordingly, it may be wise to use the term enteritis, as will be done in this article, as applying to the small intestine, the term colitis being used for the affection of the colon, and ileo-colitis for the combined involvement of the two.

The summer diarrhœas of children will not be discussed here, nor will the specific infections of the intestine.

As the catarrhal variety of enteritis is by far the most common, and for this reason the most important, both the acute and the chronic forms of this will be discussed at some length.

CATARRHAL ENTERITIS.

Catarrhal, as here used, has the common meaning of the term, that is, as indicating an inflammation of a mucous membrane characterized by a free exudation from the surface, usually rich in mucus. During life such an inflammation is evident by the presence of the inflammatory exudate which is discharged from the body, as well as by various other symptoms which are explained by the process.

ETIOLOGY.—*Acute Catarrhal Enteritis.*—The causes of this are most numerous. They may act as predisposing to, or direct excitants of, the inflammatory process. The dividing line between these two classes is frequently difficult to determine. The disease of the intestine may occur alone, or it may accompany or result from various other disorders. It is to be noticed that because of its position and the length of its canal, the small intestine is particularly liable to be affected by any kind of irritating substances which are ingested, unless these are rendered harmless in the stomach, as well as by certain excretory products which pass through its wall; and of prime importance among the predisposing factors is the ease and frequency with which an abnormal condition of the blood supply of the intestinal wall occurs, in part due to some obstruction to the returning blood in the portal system, and in part to the lack of sufficient support for the blood-vessel walls by the surrounding tissue.

An unsuitable dietary is probably the most frequent direct cause of intestinal derangement. This may be at fault only in quantity, or in quality, or in both. Food which is entirely wholesome may, when eaten in too great quantities and only partially masticated, excite a diarrhœa, as may also unripe fruit, uncooked vegetables, etc. This may be only an evidence of increased peristalsis, but often it results from a true catarrhal inflammation of the intestine. The undigested food here acts either as a mechanical irritant, or it furnishes favorable conditions for abnormal bacterial development in the intestinal canal. This microbic growth, in which the common inhabitants of the intestine chiefly take part, gives rise to a variety of active irritants. These in large part are only excessive quantities of substances normally present, chiefly acids, such as lactic, butyric, acetic, and formic, together with different kinds of gases. But besides these, substances of a more decidedly toxic nature may be formed here, probably closely resembling those referred to in the next group. This group embraces those foods which, before being eaten, have already undergone bacterial decomposition and contain poisonous products resulting from this. Such are tainted meat and fish, at times milk and its various products, etc. The active toxic agents in several of these are already known. Among these may be mentioned Vaughn's tyrotoxicon, Firth's lactotoxin, and the various ptomaïns which Brieger has isolated. At times the inflammation can be explained as due to some idiosyncrasy. Thus lobsters, cheese, eggs, etc., when entirely wholesome and in moderate quantities, may in certain individuals give rise to an acute enteritis. Foul water also frequently produces a similar disturbance.

Among the active poisons whose entrance into the alimentary canal is followed by severe inflammatory processes are included arsenic, corrosive sublimate, antimony, the mineral acids and caustic alkalies, and many others. The drastic purgatives, as croton oil, colocynth, elaterium, etc., in unsuitable doses may produce enteritis.

Exposure to cold, particularly a sudden chilling of the body after over-heating, is a recognized cause of the disease. In what way this acts, whether reflexly through the nervous system, as seems probable, or otherwise, is a question; but some disturbance of the intestinal function is produced sufficient to excite an inflammatory process. Cold drinks, ice, ice-cream, etc., when taken in immoderate amounts may have a similar result.

Excessive summer heat is also a common cause of catarrhal enteritis, particularly in young children; hence the popular term "summer complaint" so frequently applied to this. Its action is largely an indirect one, furnishing favorable conditions for bacterial growth in food before its consumption. Extensive burns of the skin may give rise to an inflammation and ulceration of the duodenum. The actual exciting agent here is probably a toxic substance which is formed at the site of the burn, and is excreted into the upper portion of the intestine.

The rôle of bacteria in producing decomposition products in various articles of food has already been referred to. No specific micro-organism can be accepted as the usual cause of enteritis, although the common colon bacillus is undoubtedly a frequent factor, due to conditions which favor its rapid development and increased virulence in the intestinal canal. Gärtner has cultivated and described a bacillus which was obtained from the flesh of a cow having an intestinal disease, and also from the spleen of a man who had been poisoned by eating some of this meat. Cultures of this produced a marked enteritis in susceptible animals. To this organism was given the name Bacillus enteritidis. Gaffky has likewise found in the stools of a cow having a bloody diarrhœa, and in those of patients who were made sick by the milk from this cow, a small highly virulent bacillus. Each of these, however, closely resembles the Bacillus coli communis, and they are probably members of the so-called colon group.

Traumatic causes, such as blows on the abdomen, may give rise to intestinal inflammation. Gall stones may mechanically produce this, as can also the presence of certain intestinal worms.

Among the more important predisposing causes is age. Young children show but slight resistance to intestinal irritants, so that even cow's milk may be sufficient to produce a catarrhal enteritis in an infant. Old and debilitated persons have an increased intestinal susceptibility and chronic congestion of the intestinal wall predisposes to the disease. Previous attacks of inflammation usually render the mucous membrane very susceptible for a time to slight irritation.

A catarrhal enteritis accompanies numerous other diseases of the intestines, as tumors, invagination, peritonitis, etc., and also occurs in many of the acute infectious diseases.

The causes of *Chronic Intestinal Catarrh* are largely those of the acute form of the disease. A severe acute attack of enteritis, when prolonged because of unfavorable conditions for recovery, may gradually pass into the chronic type. Or the repeated action of slight irritants, as indigestible food, alcohol, purgatives frequently employed, intestinal parasites, etc., may give rise to this condition. Here the process is at times evidenced by several acute attacks, or the symptoms of chronic enteritis constitute the first appearance of the disease. Anything which interferes with the nomal circulation of the blood or lymph in the vessels of the intestinal wall tends to render it susceptible to inflammatory excitants. Thus cirrhosis of the liver, chronic diseases of the lungs and heart, which give rise to a continuous overdistention of the venous system, are very frequently associated with a chronic enteritis. Continual excretion of toxic substances through the intestinal wall, as occurs in chronic nephritis, and probably also in tuberculosis, malaria, and other diseases, favors a catarrhal inflammation. Overwork of all kinds, whether physical or mental, predisposes to the disease. Secondary forms of enteritis frequently follow various gastric disturbances, as well as intestinal tumors, displacements, and adhesions.

PATHOLOGY.—*Acute Catarrhal Enteritis.*—An external examination of the intestines may show them to be considerably distended in cases of acute enteritis of some duration, this change being due to a partial paralysis of the muscular coat, or to an accumulation of gases in the canal. In severer cases, with early fatal termination, there may be a lessening of the intestinal lumen due to muscular contraction. The color, as seen from the serous surface, depends upon that of the contents of the intestines and upon the vascularity of the walls. It may be pale when the intestine is distended, red in spots corresponding to areas of congestion of the mucous membrane, yellowish due to bile, or dark red when blood pigment is included in the intestinal contents.

The appearance of the mucous membrane may vary much from what the severity of the disease would suggest. At times neither redness, nor swelling, nor increased secretion may be found post mortem, even when during life the symptoms of intestinal catarrh have been marked (Osler). It is not usual to find the whole length of the intestine uniformly involved, though this may occasionally be seen in the secondary enteritis of infectious diseases, as scarlet fever and measles. It is more common to find portions of apparently normal mucous membrane separating the inflamed areas, which may be from only a few centimetres up to a metre or more in length. The inflammatory process may be confined to a single anatomical division of the intestine (hence a duodenitis, jejunitis, or ileitis), but this is exceptional. More often the lower part of the ileum is involved, a part or the whole of the colon showing a similar condition.

The acute catarrh is characterized by a marked hyperæmia, either diffuse or localized, the latter being seen particularly in the vicinity of the lymph follicles and on the crests of the valvulæ conniventes. This congestion may be so great as to give rise to numerous punctate hemorrhages. The color varies from a bright red to purplish. But the entire wall may be gray, probably due to a post-mortem disappearance of the hyperæmia. The distention of the vessels in the more dependent loops of the intestines, due to a settling of the blood after death, is not to be mistaken for an inflammatory congestion. In rapidly fatal cases the hyperæmia may be the only macroscopic evidence of inflammation. More commonly the mucous membrane is swollen, and on its surface there is a collection of a greater or less quantity of mucus, either in a uniform layer or in small masses. This may be quite translucent, or opaque, the cloudiness being then due to the epithelial cells contained in the mucus, and not to pus formation; or it may be stained by the various substances in the intestinal canal—yellow or greenish by bile, red or brown due to the presence of blood pigment, or dark from bismuth.

The active exudation on the part of the inflamed mucous membrane is indicated by the watery character of the intestinal contents. Here at times may be found considerable masses of cast-off epithelial cells. To this condition the term *desquamative catarrh* has been applied. That this process is not entirely a post-mortem one is shown by the presence of epithelial cells in the stools during life, and the finding in the colon of hollow, finger-shaped masses of epithelial cells which cover the villi of the small intestine. The valvulæ conniventes may be thickened and the villi swollen so that the latter can be seen more easily than normal. Due to this enlargement of the villi the surface of the mucous membrane at times has a somewhat velvety appearance. Not infrequently, in severe cases of enteritis, there occurs a localized superficial necrosis of the inflamed membrane, with resulting ulceration. These ulcers are at first small, rounded, flat, with walls that show but little infiltration but may gradually enlarge (catarrhal ulcers).

The lymphoid structures of the intestine are often enlarged, appearing as grayish projections with a hyperæmic border. The solitary follicles may reach the size of a pin's head. At first they are somewhat translucent, the increase in size being then due to œdema. As hyperplasia and cellular infiltration occur they become opaque. In the agminated glands the enlargement may be uniform over the entire patch, or only single follicles or groups of these are swollen. At times these changes in the lymphoid structures are very marked (follicular enteritis). The superficial portion of the follicles may become necrotic, and by a separation of this necrosed tissue there result small round ulcers, the so-called follicular ulcers. This follicular enlargement and ulceration are seen most frequently in children and may take place very rapidly. It has been found in a child eight years old in whom death occurred two days after the onset of the symptoms (Johnston). Such ulcers may increase in size and unite with neighboring ones to form irregularly shaped ulcerated areas, in the midst of which there remain small portions of mucous membrane. In the small intestine this process is most marked at the lower part of the ileum, although here it is usually less advanced than in the colon.

Microscopically there may be seen more or less œdema and cellular infiltration of the mucous membrane. The distance between Lieberkühn's glands is frequently increased, and the epithelial cells lining these may show various forms of degeneration (mucoid, etc.). There may also be a marked proliferation of the endothelial cells of the lymph vessels. Only in the severer cases of catarrhal enteritis does the submucous layer show pronounced hyperæmia or a cellular exudate around the vessels. The muscle coat is not involved in acute catarrh.

In the lighter forms of enteritis there can be a complete recovery from the disease without leaving any permanent anatomical change behind. When the catarrh is of longer standing a complete restoration to the normal condition may not take place, but there may follow a form of atrophy of the mucous membrane in which the glandular layer is thinned. Such a resulting atrophy of some portion of the mucosa is very frequently observed in adults (Nothnagel). Small pigmented areas indicate the sites of the healed ulcers.

In *Chronic Catarrhal Enteritis* the changes from normal which are found in the intestine are fully as varied as those of the acute form of the disease. In general, the exudative processes here are less pronounced than the proliferative; the latter in turn, in long-standing cases, frequently being followed by atrophy of the affected mucosa. Also the deeper layers of the intestinal wall are involved to a greater extent than in the acute process.

The mucous membrane is at times found to be strikingly pale. This is seen not infrequently in autopsies upon small children who have died as a result of the disease. On the contrary, when a chronic congestion of the abdominal vessels has been prominent the color may be a dark red due to the hyperæmia; or altered blood pigment may be deposited in the tissue in sufficient quantities to give it a slaty hue. The pigmentation here is most marked in the vicinity of the follicles and on the villi.

In chronic as in acute enteritis the whole length of the intestine is rarely involved, but areas of diseased and of normal mucous membrane alternate. The ileum, particularly the lower portions of this, show the characteristic changes more frequently than does the jejunum or the duodenum; but the processes in the large intestine, resulting from an accompanying colitis, are often more marked than those of any part of the small intestine.

The intestinal wall becomes thickened as a result of proliferative changes occurring in it. Both the mucous and submucous coats are involved, and the glandular as well as the connective-tissue elements take part in the process. The tubules of the glands elongate, become distended, and produce abnormal quantities of mucus which appears as a layer often quite adherent to the surface of the mucosa. At the same time the glands are somewhat separated by newly formed connective tissue. When the hyperplasia is circumscribed there may result polypoid projections of the thickened mucosa, but this is less frequently seen in the ileum than it is in similar processes of the large intestine.

The subsequent changes that occur in the thickened wall are largely atrophic in nature. As the young connective tissue of the mucous and submucous coats gradually contracts, it compresses the glands of Lieberkühn, and as a result they undergo more or less complete atrophy. The villi likewise largely disappear so that the mucosa becomes thinned, and also smoother on the surface than normal.

The hyperplasia of the lymphoid tissue may be even more marked here than in acute enteritis; later, this too may atrophy, leaving behind smooth darkly pigmented spots in place of the follicles. Here also are found both catarrhal and follicular ulcers. These gradually enlarge and become deeper. They may even extend to the serous layer, giving rise to a circumscribed chronic peritonitis by which adhesions between the different peritoneal surfaces are formed.

Complete recovery, in the anatomical sense, does not occur in chronic enteritis. An atrophy of the mucous membrane, smooth pigmented dots at the site of the follicles, scars resulting from healed ulcers, or some other structural evidence of the process still remains.

SYMPTOMS, COURSE, AND DIAGNOSIS.—Catarrh of the small intestine, as already indicated, does not commonly occur alone. It is usually combined with inflammation of the colon, as an ileo-colitis; hence the symptoms observed, and as here given, both in the acute and the chronic forms, are evidences of disease in both the large and the small intestines. Those will be emphasized which are referable to the process in the latter.

An attack of *Acute Catarrhal Enteritis* usually begins suddenly, following directly upon the action of the exciting cause, the connection with which is often evident. There is at first a feeling of fulness and discomfort, soon amounting to actual pain, in the lower part of the abdomen. This pain, which is colicky or griping in nature, is quickly followed by diarrhœa. After each evacuation there is a lessening or cessation of the abdominal pain which reappears before the next movement. The number and character of the stools are important in establishing the diagnosis, and in determining the extent and severity of the process. They usually vary from two to three daily, in the lighter cases, up to fifteen or twenty or even more in the severe attacks. If diarrhœa is not present, as may happen when the small intestine alone is involved, the recognition of the catarrh becomes more difficult. In general the more the large intestine is involved the greater is the number of movements. The consistence of the first stool may be that of the normal fæces, or it may be jelly-like. The subsequent ones rapidly become more liquid, gruel-like, and later watery, and are often frothy from the admixture of gas, the result of bacterial growth. The stools at first may give the usual fæcal odor, but this soon changes, becoming more offensive. There may be a marked sour smell, particularly in milk-fed patients. Later, the watery discharges may become nearly odorless, but these if allowed to stand rapidly develop an offensive odor.

The color of the discharges depends largely upon the extent to which the small intestine is involved. When the upper portion of this takes part in the enteritis the stools vary from brown to light yellow from the presence of unchanged bile pigment; or, in children, but not in adults, they may be green from the oxidation of this. The presence of bile may be demonstrated by Gmelin's nitric-acid test. The discharges may also be variously colored by articles of food, or by medicines (bismuth, iron, etc.), and by the presence of blood. The copious liquid stools may be nearly colorless. When there is a duodenitis, with catarrhal occlusion of the common bile duct, the fæces may be very pale because of the absence of bile.

Mucus is always present in the fæces. This may be in larger or smaller shreds, readily recognized, or only in minute gelatinous particles intimately mixed with the stool. It may be unstained, colored yellow by the bile, or pigmented by the other intestinal contents. Epithelial cells, either fairly well preserved or showing various degrees of degeneration, are contained in the mucus. These may be present in sufficient numbers to give it an opaque appearance which macroscopically resembles pus, but pus cells are not often found in large number in the stools of acute catarrh. Blood, which is at times present in the stools in catarrhal enteritis in small quantities, indicates a marked inflammatory hyperæmia or ulceration.

In the early stages of the disease remnants of undigested food are frequently passed per rectum, such as pieces of meat, particles of starchy foods, etc. When these bits of meat consist of connective tissue only they indicate a disturbance of the gastric function, but when muscle masses are found they are to be referred to a disturbance in the intestinal digestion (Schmidt). Such undigested food may occasionally be found even on the fourth or fifth day of the disease, having been retained in the bowel up to this time, and having served to excite the inflammation. Bacteria are usually present in the stools in large numbers. Prominent among these will be found the normal inhabitants of the intestinal canal, but at times streptococci may readily be seen.

Among the subjective symptoms the most prominent is the feeling of discomfort in the abdomen, with the colicky pains already referred to, which precede the evacuations. This sense of discomfort may be slight and may pass off in a few hours or a day or two, but in the severer cases the suffering may be so great as to produce a feeling of faintness, with coldness of the surface and sweating. These more severe pains extend to the genitals and lower extremities. There is a feeling of thirst, but all desire for food is lost. Only when the large intestine alone is inflamed may the appetite remain. Nausea may be present, at times accompanied by vomiting even when no lesion of the stomach can be found post mortem. There is always some feeling of debility and malaise, which in children or persons weakened in any way may amount to severe prostration.

The abdomen is often somewhat distended and is tender on pressure, either diffusely or in particular regions. Loud borborygmi, due to the presence of gas in the intestine, are frequently heard. Little of value is obtained by percussion. Fever, as a rule, is not present in simple catarrhal enteritis, and when it does occur is slight in degree and passes off in a few days. On the other hand, the attack may be ushered in with a chill, followed by a pronounced rise in temperature, and a suspicion may be aroused that the case is one of typhoid fever. The spleen, however, is not usually enlarged, although Fischl describes this as of occasional occurrence.

The quantity of urine varies inversely to that of the watery stools. It may be but little changed from normal, but is frequently small in amount and concentrated. Temporary albuminuria with hyaline casts is occasionally present (Fischl), and this even in the less severe cases, without fever or collapse. The casts may be found within a few hours after the beginning of the diarrhœa. As a rule they disappear quickly as the catarrh improves. Jaundice is common when the duodenum is involved.

Such special symptoms as may occur in the secondary forms of enteritis belong rather to the primary disease and will not be discussed here.

The *Diagnosis* is ordinarily made without difficulty. Some error in diet, exposure to cold, or other etiological factor is often evident. The acuteness of the onset, the gastro-intestinal disturbance, the presence of mucus in the diarrhœal stools, slight distention of the abdomen with diffuse or localized abdominal tenderness, and loud borborygmi, can hardly be mistaken for any other condition. The febrile cases may so closely simulate typhoid fever for the first few days that a Widal's test of the blood may be necessary to eliminate this. In epidemics of cholera, the watery discharges of enteritis may so closely resemble those of the former disease that a bacteriological examination of the stools for the cholera spirillum may be necessary.

The determination of what particular portion of the intestine is involved in the inflammatory process offers more difficulty. Certain of the symptoms enumerated above are, however, sufficient to implicate the small intestine. As previously noted the upper part of this, or even its lower end when the colon is in normal condition, may be inflamed without an accompanying diarrhœa. Yet here the fæces give evidence of the condition. Mucus from the small intestine is found intimately mixed with the fæces, but not in masses of any size. The microscope may be needed to show its presence. Unusual quantities of undigested food, particularly muscle tissue, and the presence of unchanged bile pigment, are indications that the bowel above the ileo-cæcal valve is at fault. The presence of abnormal quantities of indican in the urine shows the same. Abdominal tenderness in the vicinity of the umbilicus is more marked in jejunitis and ileitis, but the severe pain produced by a colitis may be so diffused over the abdomen that slight umbilical tenderness may be of little significance. Duodenitis frequently accompanies a catarrhal gastritis, and the symptoms of the latter may completely obscure those of the former until the common bile duct becomes involved, when the resulting jaundice indicates the condition of the duodenum. A dull pain on pressure in the right hypochondriac region may indicate this even when icterus is absent.

The *Course* of the lighter forms of the disease is recovery in two or three days. In the severer types, or when the conditions for convalescence are unfavorable, this may occur only after several weeks. Still other cases gradually become chronic. After the patient appears to be entirely well there is frequently a marked susceptibility of the mucous membrane, so that slight irritants may again excite a catarrhal condition. A tendency to constipation may follow the acute diarrhœa; it is due to a partial paralysis of the muscle layer of the intestine. This may develop into chronic constipation. It is only exceptionally, and then chiefly in infants and debilitated persons, that the disease proves fatal.

Among the symptoms of *Chronic Catarrhal Enteritis* the number and character of the stools again hold the chief place. Subjective symptoms may be entirely lacking except as they are connected with irregularity in these. Whereas in acute intestinal catarrh diarrhœa is almost invariably present, this does not hold true in the chronic form of the disease. Here the stools vary much. The classification of the cases, as given by Nothnagel, depending upon the frequency and nature of the discharges, will here be followed. This includes four groups. In the first one there is constipation, the stools being from two to four days apart and frequently occurring only after a cathartic has been taken. This constipation is to be explained as due to a decreased automatic activity of the nervous apparatus, produced by the chronic catarrhal process. But with this lessened automatic activity there may be a normal or even increased susceptibility toward various irritants. The condition here is probably to be explained chiefly by a chronic catarrh of the large, rather than of the small, intestine.

The second class, which is larger, shows alternately constipation and diarrhœa, and frequently these recur with noticeable regularity. The daily stools for two or three days will be very hard; during the following twenty-four hours there will be from four to six diarrhœal discharges containing considerable mucus, and accompanied by a diffuse pain in the abdomen. Then constipation again follows. Or the stools may be normal for some days and then from four to seven diarrhœal movements, with colicky pains, follow in one day, and this is succeeded by constipation. Here also constipation is the main feature, but the decomposition of the stagnant intestinal contents produces an increased peristalsis by acting upon the fairly irritable nervous apparatus. The periodicity of the constipation may be entirely irregular.

In the third class, which includes but few cases, there is a daily movement, but this is rather soft, not well formed.

The last group comprises those cases in which for months there may be daily frequent diarrhœal discharges. In this class there is good evidence of disease of the small intestine as well as the large, furnished by the presence of unchanged bile pigment, or yellow-stained epithelial and round cells, in the stools. The condition is explained on the supposition that, because of the chronic enteritis, digestion does not proceed in a normal manner in the small intestine, and that the abnormal products (acids, etc.) formed here act in such a way as to irritate the inflamed mucous membrane of the large intestine and so keep up a marked peristalsis, causing the diarrhœa.

There are still other cases in which, owing to some nervous influence, the evacuations may occur only at night time, or early in the morning.

Of the contents of the stools, mucus is most characteristic of the catarrhal condition. This varies greatly in quantity, and may even rarely be absent in severe catarrhal conditions when the mucous membrane is atrophic. It may also at times be present in other than catarrhal inflammation; yet, in general, its continued presence in the stools, whether these are firm or liquid, may be considered an indication of an existing catarrh, although it is a fact that a thin layer of mucus often covers the hard fæcal masses of habitual constipation even without catarrh.

The conditions of odor, color, and the presence of epithelial cells and of food particles are similar to those in acute catarrh. Blood, when present, gives evidence of an ulcerative process. Indican in the urine is of the same significance as that already stated for acute enteritis.

The subjective symptoms may be few in number and inconspicuous, or they may stand out prominently. Soreness and distention of the abdomen, due to gas formation, may occur, but severe pains are usually lacking. By palpation the tenderness may be found limited to certain intestinal areas, thus indicating to some extent the parts involved. In the severer cases the abdominal symptoms may be constant, while in the others they may be called forth only by some slight error in diet, or appear as an accompaniment of a cold, or follow overexertion. The general condition is more or less disturbed. Dulness and headache frequently result from the absorption of poisonous products from the intestinal tract. The appetite is poor, nutrition suffers more and more, and the disturbances in this may assume a very grave character when a large extent of the intestinal mucous membrane becomes involved. When an atrophy of the intestinal mucosa is accompanied by that of the stomach a distinct picture of pernicious anæmia can be produced.

The *Diagnosis* of a chronic catarrh of some portion of the intestinal canal usually follows readily from the symptoms. The determination of the involvement of the small intestine is made from the stools and urine chiefly, and involves the same factors as those already given for the acute variety.

The *Course* of the disease is protracted. After months or years a functional cure may be achieved, but frequently the enteritis remains until the end of life. It is most dangerous in early childhood and in old age. By it the patient may be so debilitated that intercurrent diseases often prove rapidly fatal.

TREATMENT.—*Acute Catarrhal Enteritis.*—The treatment should be directed toward the removal of the exciting cause and the protection of the intestine against further injury. Frequently in the milder cases no medicinal treatment is necessary. The diarrhœa has expelled the irritating substances which produced the catarrh, and a temporary withdrawal of all food, or the use of small quantities of liquid nourishment only, combined with rest, is quickly followed by recovery. When, however, the colicky pains persist and the abdomen becomes distended in spite of the frequent stools, a cathartic may well be given. For this purpose either calomel or castor oil is most often chosen; the proper dose for an adult being from five to ten grains of the former, or a tablespoonful of the latter. Or the calomel may be given in small doses repeated at short intervals, and followed by a Seidlitz powder. After the action of the purgative, and with a proper restriction of the diet and rest, the symptoms generally subside. When the pain is more intense this may often be relieved by the application of warm or hot fomentations to the abdomen. Opiates are occasionally required for this purpose. After the acute pain has been relieved, a flannel bandage around the abdomen is frequently of value in keeping this warm and so preventing a recurrence of the discomfort.

If the attack is of a more severe character, and accompanied by fever, there should be complete rest in bed for a few days. When after thorough evacuation has been accomplished the diarrhœa persists, astringent and slightly antiseptic remedies may well be employed. The bismuth preparations are here particularly valuable. A very satisfactory combination may be found in bismuth salicylate (gr. vi.), zinc sulphocarbolate (gr. ss.), compound aromatic powder (gr. ij.), and prepared chalk (gr. iv.), to be given three or four times daily. Opium may be required in the more obstinate diarrhœas. The tincture of this may be prescribed in doses of from five to ten drops every three hours; or the opium may be combined with bismuth and chalk. Evidences of cardiac weakness are to be treated by the appropriate stimulants.

After the diarrhœa disappears a tendency toward constipation not infrequently occurs. This is to be treated by enemata rather than by purgatives. Also in those cases in which diarrhœa is absent from the first, when there is a history of the taking of indigestible food followed by colic and ineffectual straining at stool, a generous enema of warm water may well be given instead of a cathartic.

Regulation of the diet is of absolute importance both for cure and for prevention of a recurrence of the disease. Complete abstinence from food for the first day or two is advisable. As the appetite is usually lost this is easily accomplished. At this time such drinks as pure water, weak tea without sugar, or even small amounts of bouillon or hot diluted milk, from which the cream has been removed, are in place. These should be given in small quantities at intervals. Very cold drinks and ice should not be employed. After this brief period of abstinence from food, the patient may be allowed to take thin soups of barley, rice, oatmeal, etc., or gruels made from the common prepared foods used for infants. For many milk alone, or this diluted with barley or rice water, is all that is required. Egg albumen, scraped raw beef, toasted bread or crackers, and later lamb chops, tender steaks, oysters, etc., are easily digested. Baked or mashed potatoes are to be allowed only after the diarrhœa is completely stopped. Fruits and vegetables should be partaken of only sparingly for some time after the attack, and for weeks the patient should avoid all kinds of indigestible food. The appetite usually returns with the disappearance of the symptoms. Otherwise stomachics may be employed. In secondary enteritis the treatment becomes largely that of the primary affection.

In *Chronic Catarrhal Enteritis* the regulation of the patient's mode of life for a considerable period is of greater value than medicinal treatment. This includes avoidance of overwork of any kind, but with sufficient exercise in the open air, a simple diet composed of easily digested food taken at regular intervals, and carefulness about exposure to cold, with the wearing of sufficient warm clothing especially about the abdomen. As those cases in which chronic diarrhœa is a prominent feature are more serious than those with constipation, it may here be necessary to keep the patient in bed for some weeks in order to secure as complete rest for the system as possible, to avoid unfavorable external influences, and at the same time carefully to regulate the diet. Small amounts of food should be given frequently and regularly, but sufficient nourishment must be taken if possible to prevent loss in weight. Large quantities at a time are to be avoided. In the severer cases with diarrhœa the diet may need to be temporarily restricted to the forms of liquid food recommended above as suitable for cases of acute enteritis. But in general easily digested meats, as beefsteak, lamb chops, chicken, etc., as well as soft-boiled eggs, oysters, toasted bread with butter, baked potatoes, and similar articles may be allowed, together with soups and gruels. Most kinds of fruits and vegetables, and all foods in general that leave much undigested residue or are difficult of digestion, must be avoided, as should also very cold drinks, or those containing sugar or acid in any considerable amount, or those highly charged with carbonic-acid gas. Pure water, weak tea, cocoa, milk, kumyss, etc., are to be used but only in moderate quantities. They may be given warm or moderately cool, never ice cold.

A more liberal diet may be allowed when constipation is marked, and when the food is properly chosen the condition may often be relieved by this means alone. Soups are to be avoided as they appear to arrest peristalsis. Aside from this the articles of food above mentioned may be employed. The additions to these should be such as tend to increase the intestinal peristalsis; the physiological astringents should be avoided. Thus foods containing sugar, honey, grapes, and cooked fruits are often of value, as are also starchy foods. Fats in the form of butter or cream, chicken fat, etc., may be recommended. Generous amounts of buttermilk and kumyss may be advantageously given. But a diet which will leave a large amount of indigestible residue, such as cabbage, beets, fruits containing many seeds, etc., is to be avoided here also as liable to produce too much irritation of the intestinal mucosa. A glass of cool water taken an hour before breakfast often acts favorably.

Nothnagel has emphasized particularly the use of various mineral waters in chronic enteritis as being of much value, not merely by temporarily relieving the symptoms, but at the same time by acting beneficially upon the diseased intestine to favor the repair of the lesions. Naturally the results are more favorable when, as is exceptionally the case, the treatment can be carried out at the sanitaria connected with the various springs; such favorable results being due to some extent to the rest and regular habits there insisted on. In lieu of this the bottled waters or artificially prepared salts are to be employed. Of particular value in those cases in which diarrhœa is marked are the waters of Karlsbad and Vichy, those of Kissingen being somewhat less active. When constipation is present certain of the Saratoga waters act very favorably, as do also those from Marien bad in Austria.

Medicinally, chronic enteritis with diarrhœa may frequently be benefited by the use of chalk, or chalk and bismuth. Boas recommends the mixture, in equal parts, of the carbonate and phosphate of lime, or the addition to this chalk mixture of one-fifth its weight of bismuth beta-naphthol, a teaspoonful of either preparation being given three times daily. Cathartics should not be employed to relieve the constipation. If the regulation of the diet or the use of spring waters does not accomplish this, other laxatives may be employed; but enemata, either of plain water, or of soap and water, or containing oil in some form, are to be preferred.

When the catarrh is secondary to other chronic forms of disease, as is frequently the case, treatment is to be directed primarily toward the original disease, as frequently it is only by relieving this that the catarrhal condition can be improved.

CROUPOUS OR DIPHTHERITIC ENTERITIS.—This comparatively rare form of enteritis is characterized by the presence of a fibrinous exudate in the tissue and on the surface of the intestinal mucosa where it forms a false membrane (croupous), frequently combined with more or less coagulation-necrosis of the inflamed tissue (diphtheritic). Anatomically it closely resembles certain forms of dysentery, but the small as well as the large intestine, though to a less extent, may be involved in the inflammatory process, and it has no specific etiological factor.

Various bacteria probably play an important part in the production of this form of inflammation, but the action of these is as a rule secondary to that of other injurious agents. Thus, different mineral poisons, as corrosive sublimate, arsenic, etc., may be the primary cause, and the toxic substances supposed to be formed in certain chronic conditions, as Bright's disease, the cachexia of malignant tumors, etc., and excreted through the intestinal tract, are apparently factors in its production. It occurs occasionally in infectious diseases, as pneumonia, scarlet fever, septic processes, etc. It may develop from a catarrhal inflammation of the mucous membrane, but is not constantly preceded by this. Macroscopically the fibrinous exudate appears as a gray or a grayish-yellow layer of greater or less extent on the surface of the mucosa. It may be limited to the tips of the villi or to the crests of the valvulæ conniventes, or the patches may be of considerable size. There may be merely a very thin film of this on the surface of the membrane, or the infiltration and necrosis may extend deeply into the mucous membrane. The solitary follicles may not be involved: they may be enlarged and involved in the diphtheritic process. In the latter case follicular ulcers are common.

Diphtheritic enteritis, when occurring in the course of severe infections, may not give rise to any symptoms not referable to the primary disease. The condition is at times met with post mortem when not suspected during life. Diarrhœa and abdominal pain may exist but are not distinctive. The character of the stools shows nothing to differentiate this from dysentery. The treatment must be symptomatic, with proper attention to the accompanying disease.

Phlegmonous Enteritis is to be mentioned as a rare form of intestinal inflammation. Here there is a more or less diffuse suppurative infiltration, particularly of the submucous coat. It is caused by bacterial invasion and is nearly always secondary to other forms of intestinal disease, such as the various kinds of ulcers, intussusception, strangulated hernia, etc. The symptoms belong rather to the primary disease than to the phlegmonous inflammation. There is no clinical picture by which it can be recognized before death.

Ulcers in great variety occur in the intestinal tract, many of them, however, being found much more commonly in the large than in the small intestine. The majority of these ulcers are not the expression of an ordinary inflammatory process. Certain of them occur in specific infectious diseases, either acute or chronic (typhoid, anthrax, tuberculosis), while others result from the direct destruction of tissue by toxic agents (mercurial ulcers, etc.). Interference with the local blood supply is the probable primary cause in a certain proportion (*e g.*, duodenal ulcers), or ulcers may accompany tumor growths. None of them should be considered here. There remain as occasionally occurring in the small intestine in inflammatory processes the catarrhal and follicular ulcers, already briefly mentioned, and, rarely in the lower end of the ileum, the so-called stercoral ulcer. None of these is as common or as important here as in the large bowel. The catarrhal and follicular ulcers are expressions of the severer forms of catarrhal enteritis, either acute or chronic; hence their etiology is the same as that of this disease. A few words only as to the manner of their formation and their results are here necessary.

The catarrhal ulcer commences by a localized collection of round cells in the mucous membrane. These cells lie between and surround Lieberkühn's glands. The superficial epithelial cells over this spot are desquamated and the tubular glands destroyed, or, if the ulcer is very shallow, the lower portions of these may remain. This gives rise to small isolated, usually rounded, erosions which at first reach hardly to the submucous coat. These may heal, or may increase in size, and become confluent, forming irregular ulcerated areas of considerable size which may extend downward to the muscle coat or even give rise to perforation or peritoneal adhesions. In these larger ulcers the walls are somewhat undermined and thickened.

The follicular ulcer which begins by an increase in round cells in the lymphoid structures, with a subsequent superficial necrosis, at first appears as a minute round opening into the enlarged follicle. In the earlier stages the process is limited to the follicular tissue, the isolated ulcer being round with thickened overhanging edges. The surrounding tissue is next involved, the submucous coat being infiltrated and softened and the overlying mucous membrane becoming necrotic. By confluence considerable ulcerated areas, similar to the large catarrhal ulcers, result. Healing may occur even in catarrhal or follicular ulcers of considerable size by the formation of connective tissue, and, by contraction of this, more or less stenosis of the bowel is occasioned.

Stercoral ulcers, which are comparatively frequent in the large intestine, may at times be found in the lower end of the ileum. They are due to the presence of hardened fæces, such as may occur above stenosed portions of the intestine, or in habitual constipation. This produces a superficial necrosis of the mucous membrane, together with an inflammatory infiltration of the surrounding tissue and subsequent ulceration.

Ulcers of both the large and the small intestine may exist without giving clinical evidence of their presence. Particularly when they are limited to the small intestine and cæcum there may not even be diarrhœal movements. In general the presence in the stools of small amounts of pus mixed with a few red blood corpuscles and with mucus may be regarded as suspicious of an ulcerative process of inflammatory origin, particularly when this is accompanied by other evidences of intestinal inflammation. But there is no way by which it can be definitely determined that these ulcers are located in the small bowel. The pain which may be present in ulceration, either spontaneous or elicited by pressure, is not sufficiently characteristic to warrant a diagnosis of this condition, still less to indicate its definite location.

The treatment of ulcers, when thought to be present in the small intestine, is the same as that of the severer forms of catarrhal enteritis—viz., as complete avoidance of all forms of irritation of the bowel as possible. Large doses of bismuth may prove valuable.

Charles J. Bartlett.

ENTEROCLYSIS.—Enteroclysis, lavage of the intestines, is the title of the subject that we shall discuss, though, to speak correctly, it is but a subdivision of the larger topic, which we shall designate "Intestinal Hydrotherapy."

We would define intestinal hydrotherapy as the employment of water in the intestinal tract for therapeutic purposes, the fluid being administered through the anal orifice. This would include:

1. The enema.
2. Irrigation with a single tube—true enteroclysis.
3. Irrigation with a double-current tube, or with two tubes—also true enteroclysis.

Experiments with Enteroclysis.

We will give a résumé of the experiments which were conducted in the physiological laboratory of the College of Physicians and Surgeons (Columbia University), and which had for their object to determine the relations of this procedure to pulse tension, renal activity, and intestinal absorption; and to ascertain the effects produced by water of different temperatures. The animals employed for these experiments were dogs, and generally those of large size.

They who are interested in the technical details of the procedures will find them recorded in the New York *Medical Journal*, January 29th, 1898, and also in the author's manual, entitled "Enteroclysis, Hypodermoclysis, and Infusion."

I. *The Effect on Pulse Tension Produced by Enteroclysis with Water at Different Temperatures.*—Normal saline solution (a drachm of salt to a pint of water) was employed in all cases. With a temperature not lower than 100°

F., nor higher than 105° F., the tension of the pulse was slightly increased; with a temperature higher than 105° F., the increase in tension was more noticeable, becoming progressively greater as the temperature of the solution was increased. At 110° F. there were: marked increase in the tension of the pulse, increased rapidity of respiration, and changes in the respiratory curve. And from 110° to 120° F., there were: progressively increasing tension of the pulse, and strong heart action.

With a temperature from 90° F. down to a point as low as 36° or 37° F. (iced water), the tension of the pulse continued to increase as the temperature of the water decreased. After irrigation for about twenty minutes with water at the lower temperatures the heart action became weaker and the pressure fell.

Practical Deductions.—(1) Irrigate at a temperature of 100° to 102° F., or even as high as 104° F., if increase in pulse tension is to be avoided.

Though physiologically a slight increase in the tension of the pulse occurs at these lower temperatures, clinically none can be detected.*

(2) If a moderate increase of pulse tension is not objectionable, a temperature of 105° to 108° F. can be employed.

(3) To increase rapidly the pulse tension and stimulate the heart, employ the fluid at a temperature of 110° F., and increase the heat gradually to 120° F.

This is excellent in shock; before, or during severe operations, to prevent shock; and, from the commencement of chloroform anæsthesia, to prevent the sudden dilatation of the vessels.

(4) Cold is a temporary stimulant; later, it acts as a depressant. It should therefore be employed with caution. More patients have an idiosyncrasy as regards cold than as regards heat.

II. *Effect of Enteroclysis on Shock from Hemorrhage.*—The degree of the tension of the pulse was first noted in an animal, and then, after blood had been withdrawn from the femoral, the effects on the pulse tension and the heart were observed. The report of a single experiment will suffice:

Weight of dog, 20 lbs.; blood pressure, 155 mm.; 50 c.c. of blood removed at a time, until 509 c.c. in all had been withdrawn. Under the influence of these successive removals, the pressure fell rapidly to 112 mm. Enteroclysis was at once begun with normal saline solution at 110° F., and the heat was rapidly increased to 120° F. Immediate rise of blood pressure followed, and in ten minutes it reached 140 mm., and remained steady at this point; the heart was by this time acting with fair force (see Fig. 1913).

Deduction.—In shock from hemorrhage irrigate with normal saline solution at a temperature of 110° to 120° F., preferably at 120° F.

III. *Effect of Enteroclysis upon Body Temperature.*—Dogs were employed for the experiments, which were conducted in a room of a temperature of about 72° F. Irrigation was continued for about twenty minutes, the temperature of the water being gradually raised from 110° to 120° F. The results were: a gradual rise of the body temperature; in the axilla the increase amounted to 1° F.; the temperature of the aortic blood increased 0.5° to 0.8° F.; the tension of the pulse increasedmarkedly.

Hot irrigation was then suddenly changed to cold, the water having a temperature of 36° to 37° F., and this was continued for twenty minutes, with the following results: Axillary temperature fell 2° F.; blood temperature fell 1° F.; pulse tension at first continued high, but later it fell, and the heart action became rapid and feeble. With a temperature of from 100° to 105° F., the irrigating fluid exerted no appreciable influence upon the body temperature. Water temperatures of 105° to 110° F. caused slight increase of body temperature in the course of twenty minutes; while at from 90° to 60° F. they caused slight fall in the body temperature in the same period of time.

With enteroclysis at a temperature of less than 60° F., there was a loss of body temperature in the course of twenty minutes; but it was not very marked until the extreme degrees of cold were reached. There were idiosyncrasies in the animals. Cold at first stimulated, but, when prolonged, it depressed the circulation.

Deductions.—1. Hot irrigation at 110° to 120° F., when prolonged, increases the temperature of the body and blood, and hence its value as a means of stimulating the heart. In shock and in allied conditions its great value, especially when water at a high temperature is employed, has been demonstrated clinically.

2. In severe fevers it might not be advisable to employ enteroclysis at a high temperature, and yet it is possible that the etiological conditions may radically modify this rule.

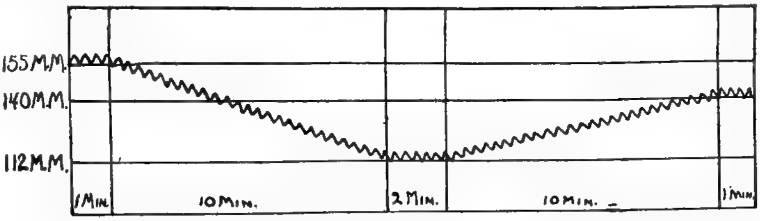

FIG. 1913.—Diagram Illustrating the Effects of Shock from Hemorrhage and its Treatment by Enteroclysis.

3. Cold irrigation reduces temperature and at first stimulates the circulation; but later it is a depressant. It has been employed to reduce temperature in dysentery, etc. I believe that it should be cautiously used and at a temperature not below 70° to 80° F. at first, and only in sthenic cases. It should be employed for a brief period, and friction during its application might be advisable.

Cold rectal irrigation is safer, and iced water has been so employed for rectal congestion for a period of over thirty minutes continuously and with a successful issue.

IV. *Effect of Enteroclysis with Water at Different Temperatures, on Renal Activity and Intestinal Absorption.*—The experiment was made in the following manner: The manometer was in each case attached to the carotid artery, to enable the observer to note the effect on pulse tension; one ureter was catheterized and the catheter was so adjusted that the drops of urine impinged on a lever supported by a tambour, each movement of which was transmitted to a second tambour, which supported a registering pen; every drop of urine was thus registered on a revolving kymograph, in the form of an inverted V. The urine was collected and measured. The opposite ureter was also catheterized and the urine measured.

Enteroclysis with normal saline solution at temperatures of from 110° to 120° F. increases renal secretion in the course of ten minutes, and very markedly so in twenty minutes. There is a marked increase of pulse tension. Note the *two cycles* of the increase of the secretion. Thus, for example, at the end of ten minutes the increase in secretion corresponds to the maximum height of the blood pressure obtained by enteroclysis at 120° F., and to the commencement of temperature increase (see experiments just described). With enteroclysis at temperatures of from 105° to 110° F., there is, at the higher temperatures, a slight increase of secretion in ten minutes and a considerable increase in twenty minutes; but at the lower temperatures there is no increase until after the lapse of twenty minutes.

With enteroclysis at temperatures of from 100° to 103° F., no increase in renal secretion is noted until the operation has been kept up for twenty minutes, and then the increase is considerable. There is a slight increase in pulse tension. Noteworthy is the single cycle of increased secretion.

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* This statement is in regard to the pure reflex effect of the temperature upon pulse tension,—not in relation to effects produced by absorption of the fluid.

That the increase in renal activity which occurred in the course of twenty minutes, from an enteroclysis with normal saline solution at temperatures varying from 100° to 120° F., was due to absorption of the fluid from the intestine, was demonstrated as follows: A weak solution of potassium ferrocyanide, 1 to 40,000, was added to the normal saline solution in each case, and the urine, as it fell into the receiving vessel, was tested every fifteen to thirty seconds with chloride of iron. On every occasion the Prussian-blue reaction was secured at the end of twenty minutes, and this occurred synchronously with the increase of renal secretion. This experiment further demonstrates the fact that intestinal absorption occurs from the large intestine (colon or rectum) in about twenty minutes.

The following interesting fact was noted: A small enema, or an enteroclysis, of normal saline solution, which had a temperature of 99° to 100° F., and which contained a weak solution of potassium ferrocyanide, produced, at the end of about twenty minutes, increased diuresis, as demonstrated by the greater number of drops of urine registered on the kymograph at this time, synchronously with the appearance of the Prussian-blue reaction in the urine in response to the chloride-of-iron test; yet no discoverable rise of pressure occurred in the manometric tracings. The increased secretion was therefore evidently due to the action of the saline solution on the kidney cells. This corresponds to the results obtained by Foster in his experiments with infusion; for this authority noted that a normal saline solution, administered in so small an amount that no rise in pulse tension could be detected with the manometer, caused a profuse diuresis.

The effects of cold irrigation on renal secretion were found to be as follows: Enteroclysis with normal saline solution at all temperatures from 100° F. to iced water (36° to 37° F.) produces diuresis in about twenty minutes, this effect being due to absorption of the fluid from the intestines. The pulse tension is increased as the temperature is lowered, and hence, by this means, secretion is further increased. With the lower temperature, however, in about twenty minutes the animal frequently goes into shock and renal secretion then ceases. Cold enteroclysis, or enemata, would seem, therefore, to be contraindicated in renal disease.

We believe that general deductions from physiological experiments on healthy animals cannot be universally applied to the human subject, and this is doubtless the true explanation why the pure physiologist quite frequently leads us to erroneous conclusions. In the practice of medicine, the results secured are often markedly modified by the existing clinical conditions. For example, enteroclysis at a temperature of from 110° to 120° F. was recommended when the pulse tension and temperature were not high. Nevertheless, I have secured excellent results in acute uræmic poisoning, with high pulse tension and a temperature of 102° F., from an enteroclysis with normal saline solution at a temperature of from 115° to 120° F., kept up for a period varying from half an hour to one hour. Profuse sweating, diuresis, and bowel action followed, and there was also a marked fall in pulse tension. Other observers have had the same experience.

If the blood-vessels are atheromatous, a great degree of heat might be undesirable. Nitroglycerin, gr. $\frac{1}{100}$, given previously to the enteroclysis, might be of value.

CLINICAL APPLICATIONS.

Hot saline enteroclysis is an excellent remedy in acute uræmic poisoning, in oliguria, in renal congestion, or in any dropsical condition due to oliguria, such as pulmonary œdema, pleurisy with effusion, ascites, etc. It aids elimination of the toxins, through the kidneys, in typhoid fever, sepsis, septic endocarditis, diphtheria, etc. Many practitioners have obtained excellent results by the employment of this mode of treatment.

A temperature of from 110° to 120° F. gives the best results, due to the double cycle of increase in the urine, attributable to the several causes heretofore noted in the account of the experiments.

Renal disease with polyuria seems to contraindicate the employment of this method; or, at all events, the existence of the latter symptom necessitates a cautious employment of the method. In a case of enlarged prostate, I found that prolonged irrigation aggravated the polyuria.

THE ENEMA.—There are two forms of enemata—the high and the low. The *high enema* is administered through a colon tube, or long catheter, to which is attached a fountain syringe, or a vessel arranged on a similar principle. The bag should hang at a height of two or three feet above the patient, and the tube should be pinched sufficiently to allow the fluid to enter slowly, so as not to excite intestinal spasm. The colon tube, well lubricated with olive oil or vaseline, is inserted into the rectum and pushed gently into the bowel for a distance of from twelve to fourteen inches. Its progress is facilitated by allowing the solution to flow, as the tube is pushed farther up into the bowel. In infants a small catheter (No. 16 or No. 18 French) can be used. The water employed for the enema should preferably be sterile (boiling it for about fifteen minutes is generally sufficient). If a Davidson syringe is used, the flow is often intermittent and forcible, exciting spasm of the bowel, and hence it is better to use the fountain syringe.

Position of the Patient.—The dorsal position, with the hips or the foot of the bed elevated, is best. The knee-elbow posture is at times employed for a high injection.

Quantity of the Solution; Temperature; Indications.—When it is desired, in a case of fæcal accumulation, tympanites, etc., to secure an action of the bowels, the following mixtures may be employed (in the case of an adult): one quart or a quart and a half of simple water at a temperature of from 101° to 104° F.; or sufficient soap (brown or castile) may be added to this to form suds; or, finally, if there is tympanites, ʒ ss.–i. of spirits of turpentine may be added to the last. Olive oil or glycerin — ℥ ss.–i.—constitutes a valuable adjunct. For the purpose of softening fæcal accumulations I have employed as much as Oss. or Oi. of oil or of glycerin at a single injection. In the case of an infant, from half a pint to a pint and a half of water—with an addition of ʒ i.–ij. of olive oil, if required—is the average quantity employed at an injection.

The enema is also of value in apoplexy and in infantile convulsions. It is important to remember that dilatation of the intestine and loss of muscular tone may result from the too frequent employment of the enema.

Kussmaul's method of oil irrigation for the treatment of chronic constipation appears to be a valuable therapeutic measure. He employs about a pint of olive oil by enema, at bedtime, injecting it slowly through a long tube; the patient lying down during the operation, first on the left side, then changing gradually to the dorsal position, and finally resting upon the right side. Gentle massage is kept up while the oil is being injected. If possible, the enema is to be retained over night.

For stimulation in shock,—to whatever cause it may be due,—in heart failure during anæsthesia, in uræmia, oliguria, suppression of urine, septic conditions, cholera, diphtheria, etc.; and as a means of replacing to some extent the loss of fluid from the body, such as occurs in gastro-enteritis and after certain surgical operations, the enema may be of great value. The fluid should be injected slowly through a long tube, with the hips of the patient, or the foot of the bed, well elevated. The retention of the injected fluid must be carefully provided for. Normal saline solution (one drachm of salt to the pint of water), at a temperature of from 110° to 120° F., should be employed for any of these conditions. In an adult the quantity to be injected at any one time should not be less than one pint nor more than two quarts, and the injection should be repeated every one to three hours, according to the indications that may be present. In children a proportionately smaller quantity of fluid should be used. In addition to the normal saline solution other solutions may be used to advantage. These are enumerated in the section on Double-Current Enteroclysis.

The method here described is of value in dysentery, typhoid, cholera, gastro-enteritis, etc. It should be more correctly classified under enteroclysis with a single tube, but it is a difficult matter to draw a sharp line of division between the two kinds of enteroclysis.

In cases of jaundice or of hemorrhage (intestinal or in adjacent organs), and in those in which it is desired simply to reduce temperature, the same method is to be employed, but the solution should have a temperature of from 90° to 70° F., or even less. Cold should be employed in sthenic cases only, and even then with caution. In cases of hemorrhage or of jaundice a temperature of from 110° to 120° F. at times gives the best results. Normal saline solution is commonly employed under these circumstances. Some advocate the injection of fresh beef blood to check intestinal hemorrhage.

For relaxing spasm, such as occurs in renal, biliary, or intestinal colic, as much as one or two quarts, at a temperature of from 101° to 104° F., is to be injected, in the case of adults. In the case of children a smaller quantity is to be employed. At times, especially in intestinal colic, a temperature of from 110° to 120° F. gives the best results.

[The nutritive enemata are described in Vol. I., under the head of *Alimentation, Rectal.*]

Intussusception.—In this condition the enema may often prove a useful therapeutic agent through its mechanical effects. When it is administered for this purpose, the patient's hips should be elevated and the shoulders depressed. Some advocate Trendelenburg's position. Emmett Holt, in the case of infants or young children, places them in the dorsal position, with the thighs flexed, and, from time to time during the injection he inverts the patient, gently manipulating the tumor through the abdominal wall. "Hydrostatic pressure should supply the force required. In the case of adults the long colon tube should be employed, while for infants a small catheter, No. 18, will be found better suited to the work. As regards the height at which the fountain syringe should be hung, I may state it to be four or five feet above the patient; this elevation giving a pressure of not over three pounds to the inch. Occasionally it may be necessary to place the bag at an elevation of six or even eight feet, in order to increase the pressure, but this is rarely advisable." (Holt.)

Experiments made upon the cadaver, for the purpose of throwing light upon this question of pressure, furnish results which are apt to be misleading; and it must be remembered that great pressure upon the wall of a viscus like the intestine, especially if it be in a damaged condition, is likely to prove dangerous.

The solution to be employed should consist either of water or of normal salt solution. Holt also advises milk and water or thin gruel as being less irritating than plain water. He advocates at times the injection of air. The injection of oxygen, as employed by Dr. Clement Cleveland, in post-operative intestinal obstruction, or paresis, should be of value (N. Y. *Medical Record*, January 5th, 1901).

"The temperature of the fluid employed should be at some point between 100° and 105° F., and in all cases an anæsthetic should be administered. The quantity of fluid to be injected should vary according to the position of the intussusception. The best guide as to the amount is furnished by *the degree of tension of the abdominal walls.* During the progress of the injection the buttocks should be held tightly together, to prevent escape of the fluid. If at any moment the tension should seem to be too great, the pressure upon the buttocks may be withheld and some of the fluid allowed to escape. As a further guide, in estimating the amount of fluid to be injected, we can remember that the colon of an infant, six months old, will hold about a pint without distention, and that, at the age of two years, it will hold two, or possibly three, pints. The adult colon holds considerably more than a gallon (Weir says nine pints, or a little over) without distention. Pressure should be kept up for from ten to twenty minutes, or even for half an hour. If the injection fails to reduce the intussusception within this time, then stop. A second attempt can be made within two hours, and if failure again results, then resort to laparotomy." This is the advice given by Holt. My own personal view is, that it is better to resort to operative interference after one failure of the injection.

The *low enema* is one in which the fluid injected does not extend beyond the rectum. For this purpose a fountain syringe, provided with the short rectal tip, well lubricated, is to be preferred. A Davidson syringe or even a suitable pattern of a hard-rubber hand syringe may be employed when only a small quantity of fluid is to be injected.

In this form of enema the patient may occupy either the dorsal or the semi-oblique or the sitting posture; and, when solutions of a high temperature are employed, it is well to lubricate the nates and the anus as far as to a point beyond the sphincter. If the enema is to be retained, the patient should assume either the dorsal posture, with the hips elevated or what is known as the Sims position.

The conditions which call for the use of the low enema do not differ materially from those which suggest the desirability of employing the high variety. In fact, the difference often amounts simply to this: in one set of cases it seems desirable to inject a small mass of fluid, while in the other a larger quantity appears to be required. Thus, in shock, uræmia, etc., from two to six ounces of normal saline solution, at a temperature of 110°-120° F., are injected; the intention being that it should be absorbed.* Such an injection should be given very slowly, and, as the tip is withdrawn, a towel should be slipped over the anus, and the buttocks should be held together for some minutes thereafter to prevent escape of the fluid. Then, again, small enemata of starch water containing ♏v.-xij. of laudanum, or of tincture of belladonna, etc., often prove useful in allaying irritability of the rectum or adjacent organs. Finally, in cases of dysentery, etc., after thorough irrigation of the bowel, enemata of this class are generally of value.

When it is desired that the fluid injected should be retained for a short time and then evacuated, the quantity employed should vary from two ounces to a pint, according to the circumstances of the case. The temperature of the fluid should vary in a similar manner; hot solutions (from 110° to 120° F.) being best suited to certain conditions, and cold (from 90° to 60° F.) to others. There are even cases—those of internal hemorrhoids, for example—in which iced water may be used to advantage. On the other hand, there are individuals who show a decided repugnance to cold enemata.

ENTEROCLYSIS WITH A SINGLE TUBE.—Enteroclysis with a single tube may belong to either of the two varieties—the high or the low. There are several methods. Thus, for example, a colon tube or large catheter is introduced into the bowel and a fountain syringe or a funnel is attached. A definite quantity of fluid is allowed to flow in, and then the fountain syringe is detached, or the funnel is lowered below the level of the patient and the solution evacuated. This procedure is repeated a second time, or several times, according to the indications, or until the fluid that returns is quite clear. As already stated above, both the temperature and the amount of the fluid employed should vary according to the individual circumstances of each case.

A Y-shaped glass tube may be attached by its stem to the rectal tube, and by its forks to the fountain syringe on the one hand, and to a carry-off tube on the other. By checking the outflow through the latter while allowing the inflow to continue, and then by arresting the latter and allowing the fluid to escape through the carry-off tube, one can irrigate the intestine in a satisfactory manner.

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* In these conditions an even larger quantity, if it can be absorbed, is preferable.

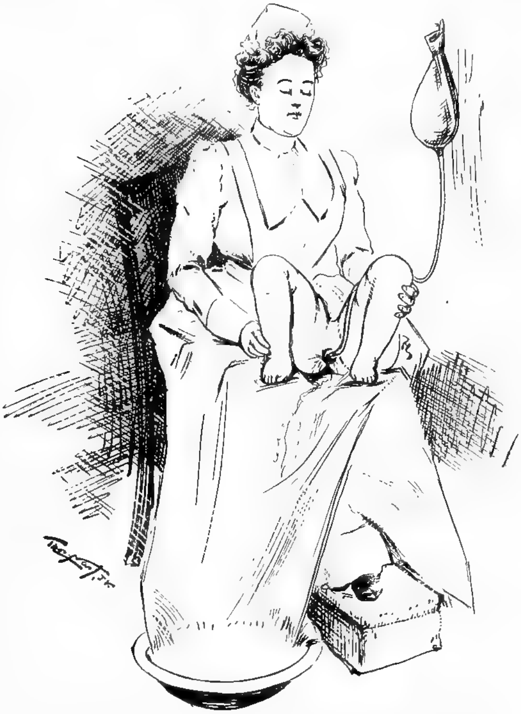

FIG. 1914.—Enteroclysis with Single Tube. Case of an infant.

Still another method is to allow the injected fluid to be ejected by the patient alongside the tube, immediately after which a fresh supply of the fluid is again injected. This operation can be repeated as often as may be desired. It will be found useful not only for cleansing purposes but also for the relief of such conditions as shock, uræmia, hemorrhage, etc. The mode of procedure, in the case of an infant, is thus described by Dr. L. Emmett Holt, who places the ileo-cæcal valve as the limit which the fluid may reach: "The child is placed on the back, thighs flexed, buttocks brought to the edge of the table, clothing protected. The fountain syringe at a height of four to five feet; a flexible rectal tube, or soft catheter, No. 18–20 American scale, is employed; an extra eye may be cut near the tip. The catheter is oiled and just after the tip is inserted into the anus the water is turned on. This renders it stiffer, and it passes more readily. It is pushed in twelve to fourteen inches. Usually a pint and often a quart will be introduced before any water returns. The water is evacuated from time to time alongside the catheter and often with considerable force; hence a towel should be spread to fall like a screen over the anus to protect the operator. The washing should be continued until the water returns quite clean. Gentle kneading of the abdomen should be employed during the early part of the irrigation to facilitate the passage of water into the upper part of the colon. The temperature, in most cases, should average 101° F. At the end of the irrigation, the tube of the fountain syringe is detached and the fluid which remains allowed to escape through the catheter before removal of the latter. The colon of a six-months' infant holds a pint without distention, and, at the age of two years, two to three pints."

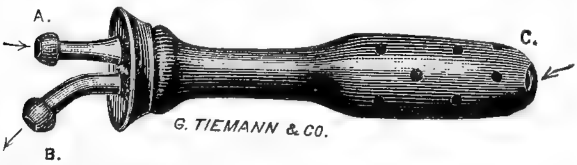

FIG. 1915.—Bodenhamer's Rectal Irrigator. *A*, inflowing stream; *B*, outflowing stream; *C*, points at which the escaping fluid enters the irrigator.

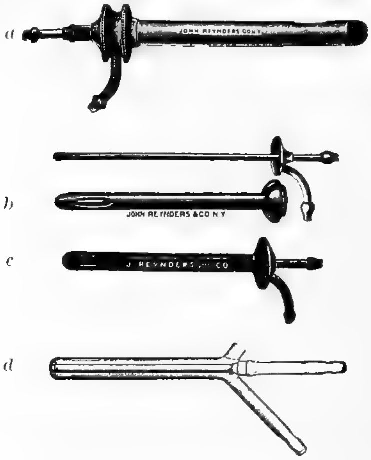

FIG. 1916.—Author's Irrigating Tubes. *a*, Flexible irrigator; *b* and *c*, more recent models; *d*, glass irrigator, with side opening (closed by a cork) for cleansing purposes.

A convenient modification of the operation is shown in the accompanying illustration (Fig. 1917).

ENTEROCLYSIS WITH A DOUBLE CONTINUOUS CURRENT.—The principle of double-current irrigation is quite old; the instrument of Bodenhamer was probably the first double-current rectal irrigator devised (see Fig. 1915). Many other irrigators have been employed, such as two tubes or catheters, or a large double-current catheter, etc. When it is necessary to improvise a double-current irrigator, this may be accomplished in the following manner: Take two catheters—the smaller one for the entering current, the larger for the outflow—and pass them through a perineal pad of gauze and cotton, covered with oiled silk, or through a dress-shield, or a piece of oil cloth, marble cloth, or rubber sheeting.

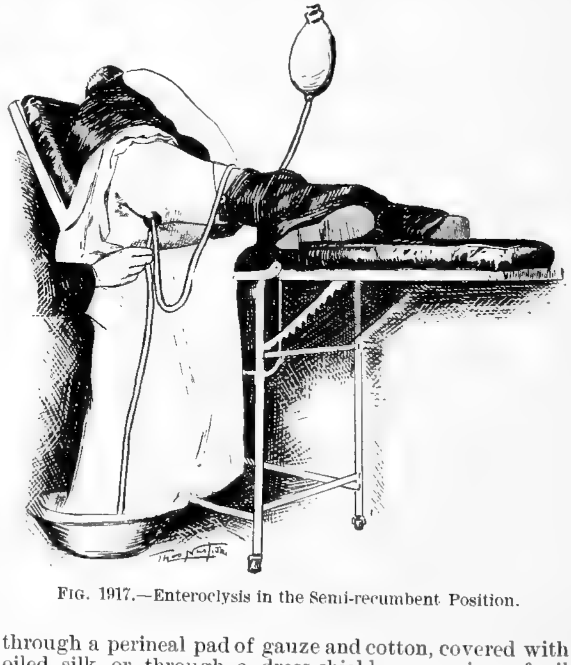

FIG. 1917.—Enteroclysis in the Semi-recumbent Position.

In the accompanying figures are shown several of the author's latest patterns of irrigating tubes (see Fig. 1916, *a*, *b*, *c*, *d*).

Precautions to be Observed before Inserting the Tube.—Allow the irrigating fluid to flow from the tube until all the air has been expelled; then check the flow. As the tip of the instrument passes through the sphincter, start the flow in order to force the mucous membrane away from the irrigator and from its fenestræ. Attach the fountain syringe to the central tube and the carry-off tube to the larger curved lateral tube. By alternately pinching this and the tube of the fountain syringe, the quantity of fluid entering and escaping can be regulated. As the outflow is larger than the inflow, unless the outflow is checked no fluid will pass up the bowel.

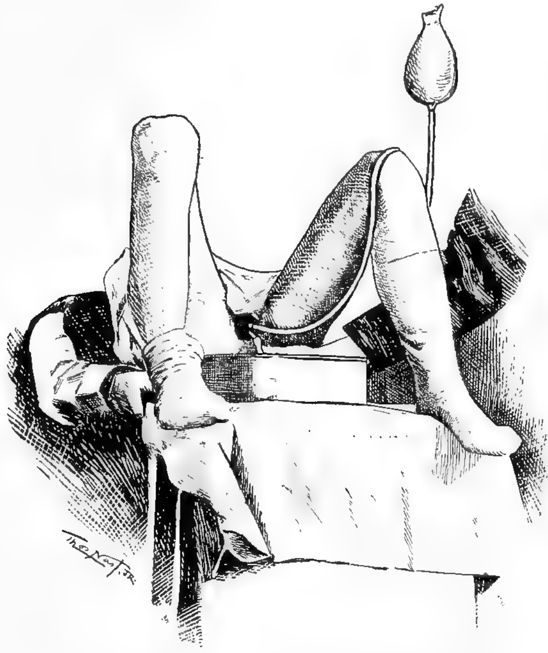

FIG. 1918.—Enteroclysis in Dorsal Position on the Bed Pan.

Insertion of the Instrument.—The tube should be well lubricated and inserted with a gentle rotary motion, and not forced in. The tip of the instrument should be directed slightly backward toward the sacrum, and the fluid allowed to flow at the moment when the tip passes the sphincter. If the flow ceases, rotate the tube slightly or withdraw it slightly while rotating, and push it back. If the outflow seems to be obstructed, stop the inflow and then force fluid back through the outflow tube with a small hand syringe, or detach the fountain syringe and force the flow back through the outflow tube for an instant. Sometimes "milking" the outflow tube with the fingers will start the flow. Avoid pressing the tip of the instrument against the wall of the bowel, or directing the current against it, as either of these procedures is irritating.

Distance to which the Irrigator should be Pushed up into the Bowel.—The rectal tube should be inserted for a distance of from one-third to one-half its length in prostatic cases, etc., and in its entire length when high irrigation is to be carried out. In actual practice it is found that the introduction of the short tube to its full length, provided the patient's hips are elevated, gives as good results in high irrigation as does the colon tube.

Withdrawal of the Instrument.—Do not withdraw the instrument like an ordinary tip, lest the mucous membrane catch in the fenestræ, but rotate it slightly, first in one direction and then in the other, as it is being withdrawn. By observing this precaution the physician will not be likely to experience the accident just described.

Cleansing the Irrigators.—To clean the stiff tubes, unscrew the central tube and withdraw it. To clean the flexible tube, unscrew the accessory cap and loosen the main cap, meanwhile holding the rubber fitting of the central tube firmly, to prevent twisting the central linen catheter; push the caps along the central tube to nearly the end, then withdraw the hard-rubber tip from the main outer tube and with it about half an inch of the central linen tube; next unscrew the tip, holding the catheter firmly just below it; and finally withdraw the central tube, as in the hard-rubber instrument. If the attempt were made to unscrew the flexible tube, it would readily tear. The flexible tubes should not be allowed to remain in any solution except for a moment, as the central tube readily softens and collapses. Should this occur, a wire passed through it generally remedies the difficulty. The central tube is often made of a linen catheter. The flexible English catheter (such as has the stylet) is much more durable; the ends do not fray so readily, nor does it crack so easily, and it is cheap. No. 7 is a good size; it can be cut in lengths to suit, and the hard-rubber fittings will cut their own thread on it. A fresh central tube can thus be used in every case, and the outer tube and fittings can be disinfected.

Enteroclysis in the Semi-oblique (Half-Sitting) Posture.—Dr. William H. Thomson's method. This has been employed in pulmonary œdema and in pleurisy with effusion, when, because of respiratory difficulty, the patient was unable to lie down (see Fig. 1917).

The Different Positions of the Body in which High Irrigation may be Practised.—The first position is that in which the patient lies upon his back, with his hips elevated and his shoulders at a lower level. A bed pan, preferably a douche pan, is placed beneath his buttocks (see Fig. 1918). This receptacle, however, may be dispensed with, as a rubber sheet, if properly adjusted, will answer sufficiently well (see Fig. 1919). The patient may also lie on either side, with the hips elevated and the shoulders at a lower level (see Fig. 1920). Instead of a rubber sheet, a Kelly's pad may be employed.

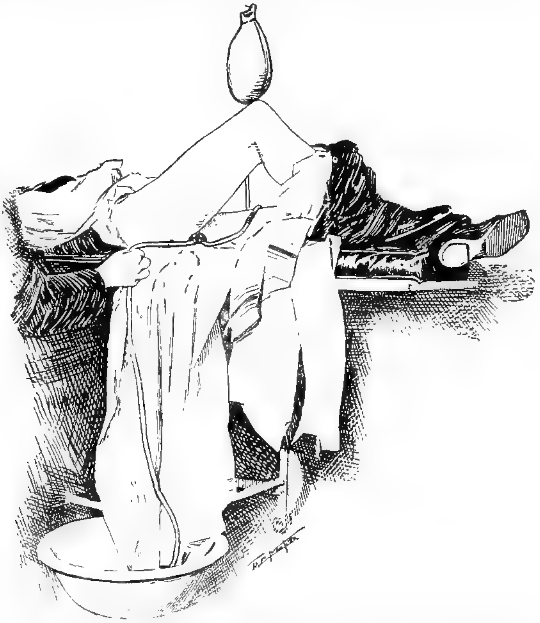

FIG. 1919. Enteroclysis in Dorsal Position without Bed Pan.

What is known as the *method by rotation* (see New York *Medical Journal*, March 13th, 1897) may be described as follows: The patient is placed on the left side, with the hips elevated, and about a pint and a half of the solution is allowed to flow into the descending colon; the outflow tube is then pinched and the patient is gradually rotated first to the dorsal position and then to the right side. As the next step in the procedure the shoulders are elevated above the level of the hips (the patient still being on the right side), in order that the fluid may gravitate into the caput coli. Then the steps just described are reversed, the outflow tube is released, and the fluid is permitted to escape. This method resembles Kussmaul's technique for irrigations with oil.

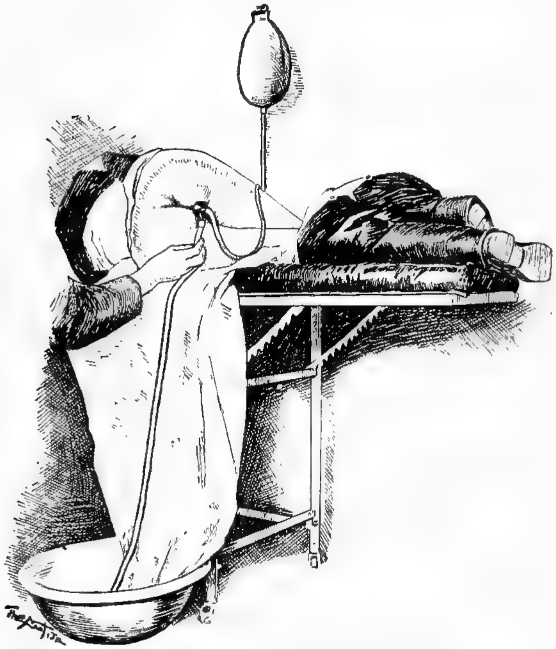

FIG. 1920.—Enteroclysis in the Sims Position.

The indications for employing double-current enteroclysis may be deduced for the most part from the following paragraphs on the "Quantity and Temperature of the Solution."

Quantity and Temperature of the Solution.—In colitis, dysentery, typhoid, intestinal dyspepsia, the various forms of diarrhœa, constipation, fæcal impaction, etc., a quantity equal to from six ounces to one pint and a half may be allowed to flow into the bowel before escape is permitted. Enteroclysis may be employed once or twice daily, and the total amount of fluid used at each sitting should not be less than two quarts. In some cases as much as several gallons has thus been utilized. If there are no special contraindicating circumstances the flow should be kept up until the escaping fluid is quite clear. The temperature of the fluid used should be from 101° to 105° F. On the other hand, in sthenic cases, if there be a high temperature—as in dysentery, gastro-enteritis in infants, etc.—irrigation with a solution at from 90° to 75° F. may be employed, to aid in the reduction of temperature. Cold should be used cautiously, and I believe that it is contraindicated if there are renal complications.

For the relief of the spasm which accompanies renal, biliary, or intestinal colic, it is a good plan to allow from six ounces to one pint of a hot fluid (saline solution at a temperature of from 101° to 103° F.) to remain continuously in the bowel for fifteen minutes or longer. At times a solution having a still higher temperature (from 110° to 120° F.) acts better. This is often the case in intestinal colic, in which condition the hot solution aids in expelling flatus.

In all conditions in which it is desirable to stimulate the circulation, to increase renal secretion when insufficient, or to eliminate toxins through promotion of diuresis, etc., the quantity of the solution to be kept continuously in the bowel should average from a pint to a quart; and the enteroclysis should be kept up for from half an hour to an hour. If we wish to secure the best results under the conditions referred to, we should employ normal salt solution at a temperature somewhere between 110° F. and 120° F. In addition to the conditions last named and to those enumerated in the earlier part of the article, the following may be named: sepsis due to any cause, as from peritonitis, septic endocarditis, cholera, typhoid, diphtheria, etc.; malarial poisoning (to check or abort a chill); the various dropsical conditions, etc.

Enteroclysis, as may readily be supposed, has proved to be of use in gynæcology. Thus, for example, its usefulness in the case of an unmarried woman, as a substitute for vaginal douching, deserves special mention. It may be employed, in the form of hot enemata of normal saline solution (at a temperature of from 110° to 120° F.), for promoting the absorption of pelvic exudations, for the relief of leucorrhœas, of ovaritis, of shock, etc., and in many other conditions (C. Reginald Hyde).

In genito-urinary and rectal affections—such as inflammation of the prostate or bladder, retention of urine, spasmodic stricture of the urethra, chronic or acute inflammation of the urethra, internal hemorrhoids, etc.—enteroclysis often affords great relief. In cases of intestinal paresis and of intestinal obstruction injections of oxygen have been found useful by Dr. Clement Cleveland, of New York. (See New York *Medical Record*, January 5th, 1901.)

SOLUTIONS THAT MAY BE USED IN ENTEROCLYSIS.

Flaxseed tea, made thin and oily, of value in catarrhal conditions of the intestine, especially if accompanied by constipation; also aids absorption of exudations.

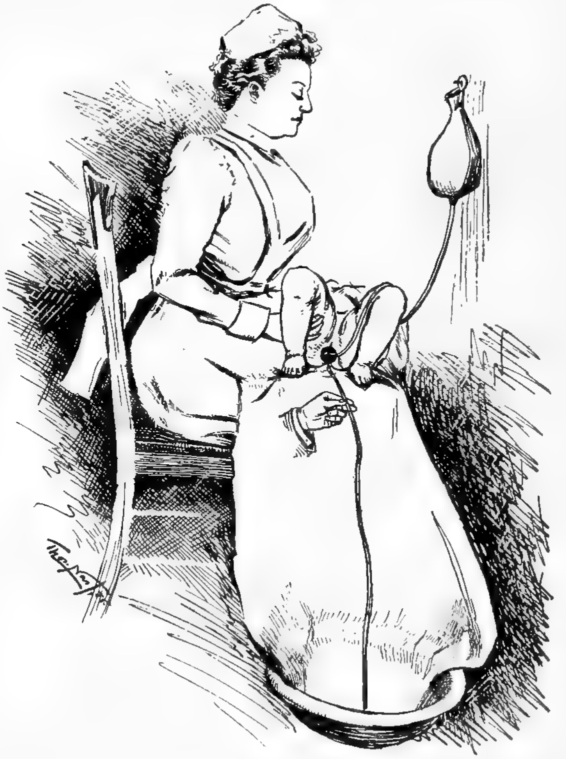

FIG. 1921.—Enteroclysis with Double Tube. Case of an infant.

Normal salt solution, a drachm of salt to a pint of water; useful for cleansing purposes; bland and especially safe for children; useful as a circulatory stimulant; as a diuretic, and to eliminate toxins.

Oil of peppermint or cinnamon (five to fifteen minims to the pint) may be added to the salt solution for cleansing purposes (William H. Thomson).

Boiled water, with boric acid (from half a drachm to a drachm to the quart, or even stronger), or with permanganate of potassium (from three to ten grains or more to two quarts of water); useful when there is marked fermentation or foul odor. A similar solution of bichloride of mercury (1 to 10,000) has been successfully employed (two quarts at each irrigation daily) in membranous (croupous) colitis of a septic type. In dysentery it is also of service. Stronger solutions do not appear to be necessary. Solutions of carbolic acid and of camphor have been found to be irritating. Rovacs and others employ quinine solutions (1 to 1,000) in amœbic dysentery. Solutions of tannin (one to two per cent.) are valuable in cholera. Tannic acid, tannin, witch hazel, and other astringents, are useful in dysentery. In chronic conditions injections of silver-nitrate solutions (gr. x.–xx. to the quart or even the pint), to be followed by normal saline solution to prevent overaction, are of service. Finally, solutions containing listerine, borolyptol, borax, bicarbonate of soda, or powdered alum (a drachm of the latter to the quart of water, or even a stronger solution), are of service.

Robert C. Kemp.

ENTEROL is a mixture of three isomeric creosols said to represent three bodies from the intestinal tract in normal proportion. It is slightly soluble in water, has an unpleasant odor, and is used as an intestinal antiseptic. It is given in pill or capsule, or in a solution of one grain to an ounce of water, usually combined with a laxative.

W. A. Bastedo.

ENTODERM, also called entoblast, and occasionally hypoblast, is the innermost layer of cells in the embryo; it is an epithelium which, in the adult, lines the digestive canal and its appendages, lungs, liver, pancreas, etc. (See *Germ Layers.*) *C. S. M.*

ENURESIS (*ἐν* = in, and *οὖρον* = urine) is a condition in which the urine is passed involuntarily or unconsciously. It is not so much a disease as a symptom common to many diseases and disorders. In childhood, however, it may be considered a separate malady, since it is often found at this age without any other accompanying symptom or lesion; in infants, up to about three years of age, it is physiological.

Mechanism.—The bladder is a fibromuscular sac which acts as a temporary reservoir for the urine. The urine does not normally escape as it falls into the bladder, and without the knowledge of the individual; but, slowly and constantly secreted, it gradually accumulates in the bladder until it can be expelled. It is retained in the bladder by the sphincter vesicæ; it is expelled by the muscular contraction of the coats of the bladder and the detrusor urinæ, assisted by the diaphragm and abdominal muscles. Normal micturition is a reflex act. As the urine gradually flows into the bladder the intravesical pressure increases, until, on a sufficient quantity being present, afferent impulses are sent from the bladder to the centre for micturition in the lumbar enlargement of the spinal cord; from this efferent impulses are sent down strengthening the inhibitory force at the neck of the bladder, and thus causing delay in the act of urination. Further, there exist a motor tract and an inhibitory tract from the brain to the centre in the cord; and, as the intravesical tension continues to rise, impulses are sent to the brain, and other impulses, now conscious, are remitted to the neck of the bladder, causing either relaxation or further tightening till a suitable time and place present themselves. The act of urination is then brought about by the relaxation of the sphincter and the combined action of the detrusor urinæ and the abdominal muscles. Any interference with this mechanism may cause enuresis.

Etiology is frequently obscure, and many conditions that are considered causes are often probably only co-existing and not causal.

Any interference with the normal mechanism of micturition, as given above, will cause enuresis; such interference can take place at the lumbar centre, or in the afferent or efferent nerve tracts, or in the brain. Other causes are: 1. In the *urine:* increase in quantity or acidity. 2. In the *bladder:* malformation, increased irritability, muscular spasm of the detrusor urinæ, non-development or imperfect innervation of sphincter vesicæ, calculus. 3. In the *penis:* phimosis, paraphimosis, elongated or adherent prepuce, balanitis. 4. Stricture of urethra and enlarged prostate in advanced age. 5. Fissure or eczema of *anus*, and worms. 6. Lesions of the nervous system—shock, hysteria, locomotor ataxia, apoplexy.

In children this distressing condition is generally due to want of development of the muscles of the bladder, chiefly the sphincter vesicæ, and to lack of proper training. It must be remembered that up to about three years of age enuresis is physiological, and that after that age proper education can do much toward inculcating good habits. Often, too, there may be a diminished sensibility of the nerves of the bladder, when the sensations are not sufficiently strong to awaken the patient, or else the sleep is abnormally deep and prolonged. Children with a neurotic tendency are often afflicted with enuresis. The trouble generally disappears at or about puberty.

Symptoms.—Enuresis may be mistaken for the "overflow" or retention of urine common in enlarged prostate, but a catheter will settle the diagnosis. Otherwise the diagnosis is clear from the statement of the patient or parent.

In children the disease is classified as (1) enuresis nocturna, (2) enuresis diurna, and (3) enuresis continua. Of these the commonest is the nocturnal variety, in which the patient is troubled only at night, but regularly every night, and this in spite of the fact that he has emptied his bladder before being put to bed. The child is apt to be gloomy and downcast, and apparently much troubled about this sad condition which is indeed his misfortune and not his fault. In some cases the trouble continues even when the patient is aroused every few hours.

The diurnal variety is caused by muscular contraction, chiefly in laughing and coughing, and is apt to persist longer than enuresis nocturna; when found after the age of puberty it is more common in the female.

Prognosis.—In children the trouble generally disappears at puberty. In any case it is well to make a thorough examination and if possible remove the cause.

Treatment.—Whenever possible remove the cause or apparent cause. Look after the general condition of the patient. In the case of children punishment and reproaches are reprehensible; the little patient probably suffers considerably from the knowledge of his affliction. Many remedies have been tried, some with a little success. Raising the foot of the bed, so that the urine does not rest on the base of the bladder, has been recommended; so, too, has electricity—the faradic current,—one electrode in the rectum, the other on the perineum.

Drug medication is largely empirical, but cures have been reported from the use of strychnine, fluid extract of ergot, iron, atropine; also nitrate of silver applied locally.

In the *Medical and Surgical Reporter* for March, 1898, is reported the case of a boy who by mistake took, four times a day, a pill of extr. cannabis indica, gr. $\frac{1}{4}$; hyoscyamine, gr. $\frac{1}{400}$; zinc phosphide, gr. $\frac{1}{8}$; and was "cured," in three days, of enuresis. *R. J. E. Scott.*

ENZYMES.—Enzyme (Gr. *ἐν*, in, and *ζύμη*, leaven), a name given to a class of chemically active substances widely distributed through the animal and vegetable kingdoms. They are chiefly of interest in medicine from the part they play in digestion, most of the chemical changes in this process being due to their agency.

In their action, enzymes present many points of striking resemblance to ordinary ferments, such as bacteria, yeast, moulds, etc. For example, both classes work best at about the same temperature, viz., that of the human body, or a few degrees above it; each is destroyed by boiling; each will cause insoluble substances to be transformed so that they pass into solution. This similarity caused earlier observers to classify the enzymes as a special group of ferments. To distinguish them from the micro-organism ferments, they were called "unorganized ferments," "soluble ferments," "formless ferments," "unformed ferments," etc. All of these names are still in use at present, but the term *enzyme* has been the most favored one since the classical work of Kühne (1878), as it avoids confusion with ordinary fermentation. The advantage of this has been pithily expressed by Sheridan Lea, in "Foster's Physiology," as follows: "It appears advisable to use the term 'enzyme' to denote the soluble unorganized ferments generally, reserving the older name of 'ferment' for the organized agents such as yeast to which it was first applied. If this be done it will be convenient to use the expression 'zymolysis' to denote the changes produced by the enzymes in their action on other substances and to apply the term 'fermentation' to the action of the organized ferments. In this way 'zymolysis' corresponds to the German 'Ferment-Wirkung,' and 'fermentation' to 'Gährung.'"

In 1874, Musculus showed that an enzyme could be obtained from urine which contained the Micrococcus ureæ, and that the enzyme would produce the same decomposition of urea that was brought about by the living micrococcus. In 1885 Sheridan Lea found that this enzyme could be isolated from the micrococci. A number of similar discoveries have been made with other micro-organisms and moulds. Even the ordinary alcoholic fermentation produced by yeast has been brought within this category by the classical researches of Buchner; so that it is by no means improbable that the decomposition processes of fermentation may yet be shown to be those of zymolysis, the living micro-organism producing the enzyme, and the enzyme bringing about the chemical changes (see article *Fermentation*).

CHEMICAL COMPOSITION OF THE ENZYMES.—It is extremely difficult to get any of the enzymes even approximately pure, and it is doubtful whether an absolutely pure specimen has ever been obtained. For this reason the chemical nature of the enzymes is still undetermined. It is generally admitted that they contain nitrogen, and they have usually been classified as proteids. The purest specimens obtained a decade or more ago gave a number of reactions common to proteids, but it must be remembered that they are always obtained from close association with proteids in the cells from which they are derived, and the question has arisen whether or not the proteid did not cling to them as a contamination. As methods for their purification have improved, specimens have been obtained which gave fewer and fewer of the proteid reactions, until now the trend of opinion is away from the old theory of their proteid nature—but we have found nothing definite to take its place.

Theories widely different from the above find a place even in the most recent literature, the enzymes being regarded by some as imponderable, immaterial forms of energy "clinging to changing chemical substances, like electricity to a conductor" (Arthus, Thèse, Paris, 1896). The latest writer whose monograph has appeared on the subject (Oppenheimer, 1900) defines enzymes as follows: "An enzyme is the material substratum of a peculiar form of energy, which is produced by living cells and which clings to them more or less tenaciously without their action being bound up with the life process as such. This energy is able to bring about the freeing of the potential energy of chemical substances, and to transform this into kinetic energy (heat, light). The chemical substances are altered in such a way . . . that the products of the decomposition shall collectively represent less potential energy than is represented in the original substance," etc. He explains that he uses the term "material substratum" "because we are absolutely in a fog as to our knowledge concerning their chemical nature."

MODE OF ACTION OF ENZYMES.—*Temperature.*—Each enzyme has a temperature at which it acts best. This varies with the enzyme: at a definite point of low temperature its action is suspended, but the enzyme is not destroyed; at a higher temperature its action is suspended, and at a still higher point the enzyme is destroyed. In the moist condition this destruction occurs at the boiling point, or below it, while some enzymes may be heated dry to 150° C. and still be active when placed again in solutions at the proper temperature.

Action of Enzymes Hindered by the Accumulation of the Products of Their Own Activity.—Most enzymes cease acting when the products of their activity reach a certain concentration. If pepsin be made to digest fibrin it stops acting when the proteoses and peptones reach a certain concentration, but will begin acting again if the mixture be simply diluted with water or with some other appropriate fluid.

Relation of Quantity of Enzymes to Work which they Do.—The quantity of enzyme will determine the rapidity of actionbut not the amount of action. One grain of pepsin will dissolve as much proteid as an ounce, but it will require a longer time.

Enzymes Not Used Up.—This is one of the most remarkable properties of enzymes. After causing an enzyme to transform a large amount of substance on which it acts, there is still so nearly as much enzyme present as there was at the beginning that it may be regarded as practically the same.

NATURE OF ACTION OF ENZYMES.—A discussion of the nature of zymolysis would lead us back to the classical discussion, between Liebig and Pasteur, of the action of ferments in general (see article *Fermentation*). The predominant action of the digestive enzymes is one of hydrolytic cleavage; that is, the enzyme will cause the substance acted upon to take up water and then split into two different substances, usually of the same class. This is well illustrated by the enzyme "invertin" of the intestinal juice in its action on cane sugar. The cane-sugar molecule, in the presence of invertin, takes up a molecule of water and then splits into dextrose and levulose as follows:

$$\underset{C_{12}H_{22}O_{11}}{\text{Cane sugar}} + \underset{H_2O}{\text{water}} = \underset{C_6H_2O_6}{\text{dextrose}} + \underset{C_6H_{12}O_6}{\text{levulose}}$$

It will be noticed that the enzyme is not shown in the reaction, as studied by its end products, and yet the reaction will not take place in simple aqueous solution without the presence of the enzyme; moreover, the enzyme is not used up, no matter how much cane sugar it converts. The exact mode of its action is not understood. The most plausible theory which has been advanced and the one which meets with most acceptance is that the enzyme acts as a go-between or carrier for water very much in the same way that NO acts for oxygen in the manufacture of sulphuric acid. Here sulphur is burnt in the air forming SO_2, which readily combines with water (steam) to form sulphurous acid, H_2SO_3. Sulphurous acid will unite with oxygen to form sulphuric acid:

$$\underset{H_2SO_3}{\text{Sulphurous acid}} + \underset{O}{\text{oxygen}} = \underset{H_2SO_4}{\text{sulphuric acid}}$$

but the process is too slow to be practicable. If, however, nitric oxide and air be introduced the action becomes rapid and continuous in the following way: The nitric oxide, NO, takes up oxygen from the air and becomes nitrogen peroxide, NO_2. This NO_2 readily gives up part of its O to the H_2SO_3, and is transformed back to NO.

$$\underset{H_2SO_3}{\text{Sulphurous acid}} + NO_2 = \underset{H_2SO_4}{\text{sulphuric acid}} + NO$$

As soon as it becomes NO it takes a fresh supply of O from the air, only to be robbed of it promptly again by a fresh supply of H_2SO_3, so that the process goes on continuously, the H_2SO_3 becoming transformed into H_2SO_4 the NO acting as an oxygen carrier and not being used up. In practice the process is even more striking: SO_2 from burning sulphur, H_2O (steam) and NO_2 are sent into a common receptacle where they mix with air and with each other. The reactions are then as follows:

$$(1)\ SO_2 + H_2O + NO_2 = H_2SO_4 + NO$$
$$(2)\ NO + O = NO_2$$

and so on continuously.

Sulphur and water are transformed, together with oxygen from the air, and the end product is sulphuric acid. A study of the end product does not show the intermediate product H_2SO_3, nor the action of the NO and NO_2 as a carrier of the oxygen. In the case of the enzymes we have been able to study satisfactorily only the substance transformed and the end products. The intermediate reactions have not all been determined, so we can reason, as to the rôle of enzymes, only by analogy with better known cases, such as the example chosen of sulphuric acid.

DETERMINATION OF THE ACTIVITY OF ENZYMES.—The various preparations—most of them proprietary—depending for their action on the enzymes which they contain, are mostly mixtures of enzymes with a certain amount of foreign matter. This is notably true of preparations from the stomach (pepsin) and from the pancreas. Much has been claimed for and against the relative merits of certain of these preparations. The method of investigation depends upon the enzyme which is being investigated, and for the details of standard methods the reader is referred to works on physiological chemistry. All methods, however, involve one fundamental procedure, viz.: to determine the amount of substance transformed by a given amount of enzyme in a given time; or to determine the amount of enzyme necessary to transform a given amount of substance in a given time; or to determine the time required for a given amount of enzyme to transform a given amount of substance; in other words, there are three factors in the process: time, strength of enzyme, and amount of substance transformed; if two of these are known the third can be determined. It must never be forgotten that all comparisons of enzyme-activity must be made under rigidly the same conditions as to the physical state of the substance acted on, the fluid medium in which it is placed, temperature, cleanliness of vessels, etc. Slight differences in these conditions, especially the physical condition of the substance acted on, will give results which are absolutely incomparable. This point should never be overlooked in comparing the results of one series of experiments with those of another.

ORIGIN OF ENZYMES.—In the vegetable kingdom, enzymes may be extracted from the lower organisms such as bacteria, yeast, moulds, etc., while higher in the scale they play an important part in the plant economy, causing the solution of stored-up foods such as starch and even cellulose. This is especially well marked in germinating seeds. In some of the highest forms, such as certain pitcher plants (Nepenthes) there are well-developed cells resembling gland cells which secrete enzymes capable of digesting insects which the plant catches.

In the animal kingdom observations have been made which suggest that even in the lowest forms, such as the amœba, digestion is carried on by enzymes made by the cell and collected in vacuoles. Fredericq has isolated a digestive enzyme from sponges; and certain worms and cephalopods (snails) have been sufficiently well studied to leave little doubt that digestion is carried on by enzymes secreted by glands. In the higher vertebrates, practically all the digestive enzymes are secreted by glands, and the preparation of these enzymes appears to be the chief work for which the glands are set apart. The enzymes do not exist as such in the glands, as is shown by the following experiments: If the stomach or pancreas of an animal be cut out, immediately after death and thrown into alcohol, it will yield very little enzyme. If, however, it be allowed to stand for several hours (twelve to twenty-four), the yield of enzyme will be considerable; hence we suppose that the living gland cells contain, not enzyme, but a substance which can readily be transformed into enzyme. To this substance the general name *zymogen* is given. In the case of specific enzymes, we use the specific name of the zymogen: thus, pepsinogen is the zymogen from which pepsin is formed, trypsinogen is the zymogen from which trypsin is formed, etc.

Microscopic investigations on the gland cells give still further support to the zymogen theory. If the cells of a gland be examined when the gland has been at rest for some time—that is, when it has not poured out an abundant secretion for several hours—the cells will be found to be packed full of granules, so as to obscure the nuclei and the boundary between the cells. After the gland has been actively pouring out its secretion, these granules disappear to a considerable extent, but the cell fills up with granules again on resting. These changes in the activity of the gland and in its histological appearance may be brought about by stimulating certain nerves to the gland, and those nerves which cause the greatest disappearance of granules make the gland produce a secretion richest in enzyme. This has been well demonstrated for the salivary glands for a number of years, and recent observations have confirmed the same for the stomach and the pancreas.

FATE OF THE ENZYMES IN THE HUMAN BODY.—The urine contains a small amount of pepsin, amylolytic ferment, and rennin. (The occurrence of trypsin in normal urine is doubtful.) A certain amount of these ferments may therefore be regarded as gotten rid of normally in this way, but it is at best of secondary importance, as shown by Béchamps and Balthus for amylolytic ferments and by Schnappauf for pepsin. These observers injected the enzymes in question into the blood and found that there was no such increase of them in the urine as should have been produced if the kidneys had been active in excreting them. Most of the digestive enzymes are rendered inert or actually destroyed in the alimentary canal, and they or their residues pass out with the fæces. Enzymes are not dialyzable, so we should not expect them to get into the blood in any considerable quantity, and when injected into the blood they are destroyed in the system (probably to some extent in the blood itself). This process is probably a slow one as shown by the interesting researches of Hildebrandt. The enzyme emulsin breaks up the glucoside amygdalin from bitter almonds, with prussic acid as one of the decomposition products. Hildebrandt injected emulsin subcutaneously into rabbits, and found that it gradually disappeared from the blood without being excreted by the kidneys. At different intervals after injecting the emulsin he administered amygdalin, and the presence of the emulsin was indicated by symptoms of prussic-acid poisoning. He got this effect as long as six hours after injecting the emulsin, showing that the enzyme had not all been destroyed in this interval. After the blood had ceased to give the reaction for the enzyme, it was still found in the spleen and pancreas, and especially in the liver and in the lymph glands in the region where the hypodermic injection was made—showing that certain organs outside the blood could bind and hold the enzyme (and ultimately destroy it).

CLASSIFICATION OF ENZYMES.—Enzymes are classified in two different ways:

A. From a chemical standpoint, according to the kind of action they induce.

B. According to the class of substances on which they act.

Classification A is the more logical, but classification B is more convenient, and is by far the more generally used.

From a chemical standpoint, as above, Hoppe-Seyler gives the following classification (quoted, modified, from Halliburton):

(*a*) *Ferments which Act Like Dilute Mineral Acids at 100° C.:*

I. Change of starch or glycogen into dextrin and grape sugar:

$$\overset{\text{starch}}{(C_6H_{10}O_5)_4} + 3H_2O = \overset{\text{dextrin}}{C_6H_{10}O_5} + \overset{\text{glucose}}{3C_6H_{12}O_6}$$

II. Change of cane sugar into dextrose and levulose (inversion):

$$\overset{\text{cane sugar}}{C_{12}H_{22}O_{11}} + H_2O = \overset{\text{dextrose}}{C_6H_{12}O_6} + \overset{\text{levulose}}{C_6H_{12}O_6}$$

III. Changes of various benzoyl glucosides into sugar, and simpler benzol derivatives by the action of emulsin. Example:

$$\overset{\text{salicin}}{C_{13}H_{18}O_7} + H_2O = \overset{\text{sugar}}{C_6H_{12}O_6} + \overset{\text{saligenin}}{C_6H_4\left\{\begin{matrix} CH_2OH \\ OH \end{matrix}\right.}$$

IV. Decomposition of sulphur-containing glucosides into glucose, sulphuric acid (acid sulphates) and oil of mustard by the action of myrosin. Example:

$$\overset{\text{potassium myronate}}{C_{10}H_{18}NS_2O_{10}K} = \overset{\text{glucose}}{C_6H_{12}O_6} + HKSO_4 + \overset{\text{mustard oil}}{C_4H_5NS}$$

(*b*) *Ferments which Act Like Caustic Alkalies at a Higher Temperature. Fermentative Saponification:*

I. Decomposition of esters (fats) into an alcohol (glycerin) and an acid (fatty acid):

$$\overset{\text{tristearin}}{C_3H_5(C_{18}H_{35}O_2)_3} + 3H_2O = \overset{\text{stearic acid}}{3(C_{18}H_{36}O_2)} + \overset{\text{glycerin}}{C_3H_5(OH)_3}$$

II. Decomposition of amido compounds with absorption of water. Examples:

$$\overset{\text{urea}}{CO(NH_2)_2} + H_2O = \overset{\text{ammonium carbonate}}{(NH_4)_2CO_3}$$

$$\overset{\text{hippuric acid}}{C_9H_9NO_3} + H_2O = \overset{\text{glycine}}{C_2H_5NO_2} + \overset{\text{benzoic acid}}{C_7H_6O_2}$$

The decomposition of proteids and albuminoids with the formation of leucin and tyrosin, as effected by the ferment trypsin from the pancreas, belongs in the above category. The proteids are in all probability amido bodies, but the formulæ are too complicated and the reactions too little understood to illustrate them as was done with the simpler compounds above.

The chemical classification given above, while classical, is difficult of general application, for in many instances our knowledge of the changes produced by enzymes is not sufficiently accurate to justify a direct comparison with well-determined chemical reactions. Again, in the biological field (whether animal or vegetable), where we meet enzymes, we have our attention concentrated on the substance affected (usually food) rather than on the chemical action of the enzyme. This has led to a somewhat mixed classification, based partly upon the character of the substance acted on by the enzyme, and partly upon the grosser and more apparent changes produced rather than upon delicate resemblances of chemical action.

In practice, therefore, biologists, almost universally, adopt some such classification as the following:

(1) Proteolytic enzymes.
(2) Amylolytic enzymes.
(3) Fat-splitting enzymes.
(4) Sugar-splitting enzymes.
(5) Coagulating enzymes.
(6) Oxidizing enzymes.
(7) Glucoside-splitting enzymes.

(1) Proteolytic enzymes. Those which act on insoluble proteids transforming them into soluble ones. In this group belong:

I. Pepsin in gastric juice.
II. Trypsin in pancreatic juice.

And these are often used generically for a whole group of enzymes resembling them. Thus one often hears of vegetable pepsins and vegetable trypsins according as the ferment in question resembles pepsin or trypsin in its final action. Pepsin (and the pepsins) transform insoluble proteids into peptone as the final stage of its action; peptone is a proteid. So pepsin never goes beyond the proteid class. Trypsin goes a step further and breaks the peptone down into a group of amido decomposition products of which leucin, tyrosin, and asparagin are the best-known examples.

III. Proteolytic enzymes in the vegetable kingdom. These are very widespread and various. They may be extracted from the lowest forms (bacteria) and in some cases produce the liquefaction of gelatin cultures. They are found in many stems, roots, leaves, and fruits of higher plants, and in certain pitcher plants they are secreted by a gland-like structure, and have the function of dissolving insects and other proteid food which the plant catches.

Two of these vegetable proteolytic enzymes—papain from the pawpaw and bromelin from the pineapple—have been very thoroughly investigated by Chittenden and his pupils, and may be said to be among the best understood of the enzymes.

(2) Amylolytic [diastatic] enzymes. Those which act on starch and carbohydrates of the starch group transforming them into soluble carbohydrates.

In this group belong:

I. Ptyalin in saliva.

II. Amylopsin in pancreatic juice.

III. Diastase in malt. This is one of the oldest and best-known members of the group and from it the name *diastatic* is derived as a generic term for the group.

IV. Enzymes of the diastase class have been discovered widely spread in the vegetable kingdom from bacteria to the highest plants. Among the organisms, of interest in medicine, which transform starch into sugars probably through the action of such an enzyme may be mentioned, the spirillum of cholera, Bacillus mesentericus vulgatus, and the moulds Penicillium glaucum, and Aspergillus niger. Some of the vegetable diastases are on the market in medicines to aid digestion.

V. Amylolytic enzyme in the liver. It is well known that the liver stores up carbohydrate food in the form of glycogen, and that it gives this out to the blood, as needed, in the form of glucose. It is also well known that after death glycogen rapidly disappears from the liver, glucose being found in its place. Some authorities attribute this transformation, both during life and after death, to an amylolytic enzyme in the liver. This point is still in dispute.

VI. Digestive juices, indicating by their action the presence of amylolytic enzymes, have been found in the animal kingdom as low as rotifers. The enzyme has been isolated in secretions from insects. In man, and in the mammalia generally, such ferments occur in appreciable quantities in the intestinal juice (succus entericus), the liver, and the muscles. In all these situations they have a rôle more or less important. Blood and lymph also contain them, as do nearly all the fluids and tissues of the body. Just how much of this is made in the tissues and how much is carried to them by the blood is an open question.

It is still a disputed point whether the animal and the vegetable amylolytic enzymes are the same. The weight of authority seems to be in favor of the view that they are different.

(3) Fat-splitting [steatolytic] enzymes. Those which break up fats into glycerin and fatty acid. The principal member of this class is—

I. Steapsin [pialyn, lipase]. This enzyme is found in pancreatic juice.

II. Enzymes similar to steapsin in their effects are found in the vegetable kingdom, especially in certain seeds which contain stored-up fatty substances. The enzymes bring these into solution at the proper time.

III. Fat-splitting enzymes are present in invertebrates as low as sponges (Fredericq). They are also found in the eggs of certain Crustaceans.

IV. Fat-splitting enzymes in the blood: Henriot has described an enzyme of this class in the serum. Cohnstein and Michaelis think such an enzyme exists in the red blood corpuscles.

V. Some observers claim to have found a fat-splitting enzyme in the stomach. This has not yet been generally accepted.

(4) Sugar-splitting enzymes. Those that split di-

saccharides, like cane-sugar, into monosaccharides, like dextrose and levulose.

I. Invertin [invertase], found in the intestinal juice, splits cane sugar into dextrose + levulose. Found also in plants, certain bacteria, and moulds.

II. Another enzyme [maltase], also found in the intestine, splits maltose into dextrose. Found also in plants, bacteria, yeasts, and moulds.

III. Lactase. Found in the intestine (?). Found also in the kephir organism. It splits milk sugar (lactose) into dextrose + galactose.

IV. Raffinase [melibiase], melizitase, trehalase. These are all new enzymes discovered and described within the last few years. They are found in yeasts and moulds, and have characteristic actions on rare sugars. They throw light on the composition of these sugars by breaking them up into well-known forms, and it is possible they may become of commercial value in connection with special forms of fermentation.

(5) Coagulating enzymes. Those whose action is marked by the production of a coagulum, curd or jelly. There are four well-known members of this group:

I. Rennin [rennet, chymosin], found in the mucous membrane of animals, especially young sucking animals; and in the pancreatic juice of many animals, including man. It is also found in the vegetable kingdom. It produces a sweet curd in milk which is different physically and chemically from the curd which is formed when milk sours. It is used to curdle milk in cheese manufacture. The rennin for this purpose is usually obtained from calves' stomachs, but it is interesting to note that in some rural districts plants (galium verum) are put into the milk to produce the curd, and in this case the action is due to vegetable rennin.

II. Fibrin ferment [thrombin, thrombase]. Found in shed blood during and after coagulation—absent from blood circulating in living blood-vessels. It causes the fibrinogen of blood to unite with calcium salts and to form a jelly-like clot which later becomes fibrous (fibrin). The origin and nature of fibrin ferment are still much disputed. Some deny that it should be classed with enzymes at all. Schmidt, who discovered it and described it (1872), classed it with the enzymes and said it was derived from the white corpuscles of the blood. Hayem (1878) and Bizzozero (1881), in classical researches on blood plates, claim that the blood plates break down when blood is shed and that the white corpuscles do not. The majority of observers who have studied coagulation under the microscope, with the greatest precaution, agree with Hayem and Bizzozero. On the other hand, those who have attacked the problem from a chemical standpoint particularly, tend to class fibrin ferment with the nucleoproteids and to derive it from leucocytes, because it may be so manufactured from tissue rich in these corpuscles. This fits several cleverly conceived theories of coagulation which are far from proved, and is, on the whole, attractive, but it should not outweigh the opinion of the majority of direct observers, viz., that in normal coagulation the leucocytes do not break down. It is commonly taught in text books that fibrin ferment is derived from blood plates and leucocytes, both of these elements breaking down when the blood is drawn, but this is at best an unsatisfactory compromise. The whole question must be settled by further research. (For fuller details on fibrin ferment see *Coagulation.*)

III. Myosin ferment, may be isolated from muscles which have gone into *rigor mortis.* It causes the plasma of muscle to coagulate as it does in *rigor mortis,* with the production of death-stiffening. This enzyme is found only in the animal kingdom.

IV. Pectase. Found only in the vegetable kingdom. It has to do with the formation of many of the vegetable jellies which may be made from fruits. It probably plays an important part in the plant economy, acting on pectose, a substance found associated with cellulose in the cell wall.

(6) Oxidizing enzymes [oxidases]. This class of enzymes was one of the latest to be discovered and investigated. A number of phenomena hitherto unexplained are now being attributed to oxidizing enzymes. The rôle of certain oxidizing enzymes in the vegetable kingdom has been fairly well studied. In the manufacture of wine, for instance, certain processes which were thought to be due exclusively to bacterial fermentation are now known to be produced by enzymes which can be extracted from the bacteria, and which can work independently of them. It has even been claimed that the delicate bouquets of certain wines may be produced in this way, without the presence of the micro-organism.

In the animal kingdom the presence and function of oxidases are not well determined. It has long been known that a certain amount of oxidation takes place in blood shortly after it is drawn. Certain reducing substances, such as dextrose, disappear; and less oxygen can be recovered *in vacuo* after the blood has stood free from exposure to the air. Within the last decade this has been shown to be due, in great probability, to an enzyme which oxidizes.

Removal of the pancreas causes a marked diabetes, and much can be said for Lépine's theory—that the pancreas manufactures an oxidizing enzyme which is taken up by the blood, and that when this is present it keeps the percentage of sugar in the blood so low that it does not appear in the urine. Abelous and Biarnés found that sugar was also destroyed by the testis, thyroid, liver, kidney, lungs, and spleen. Spitzer (1897) thinks these tissues owe their oxidizing power to nucleo-proteids.

Hammersten has described an enzyme (oxidase) in the stomach mucous membrane which oxidizes milk sugar (lactose) to lactic acid.

(7) Glucoside-splitting enzymes. Those which break up glucosides into glucose and various other substances depending on the glucoside. This group of enzymes is one of the most interesting, from a chemical standpoint, of all the enzymes. Some of its members were the first to be discovered and investigated. Myrosin, as the active principle of mustard seed, was pointed out by Lefèbre in 1660, and again by Boerhave in 1775, while the classic researches of Robiquet and Boutron-Chalard (1830) and of Liebig and Wöhler (1837) on myrosin and on emulsin were epoch-making in our knowledge of the action of enzymes in general. In later years they have played a no less important part in the work of E. Fischer on the synthesis and structure of sugars, which has led to some of the most brilliant and valuable discoveries of modern times in the field of organic chemistry. These enzymes do not occur in the human body, so they will not be described in detail. The members of the group are:

I. Emulsin—long known to exist in bitter almonds, found also widely in the vegetable kingdom from flowering plants to mosses, where it plays an important part in plant economy. Its presence in bacteria is disputed. It breaks up amygdalin, in bitter almonds, into glucose, prussic acid, and oil of bitter almonds. It also acts on a number of other glucosides.

II. Myrosin, found in mustard seed. It breaks up potassium myronate in the seed and liberates mustard oil.

III. Gaultherase, found in wintergreen. It liberates oil of wintergreen from the glucoside gaultherin found in the plant.

IV. Other enzymes of this group are: erythrozyme in madder root, rhamnase in Persian berry, and a new enzyme lately discovered in connection with the manufacture of indigo. It was formerly thought that bacteria were necessary for the decomposition of the glucoside indican in the manufacture of indigo, but the researches of Lookeren-Campagne (1894) and of Bréaudat (1898) make it appear probable that the action is one of zymolysis. Bréaudat gives the reaction in two stages: (*a*) the formation of indigo white by a hydrolytic enzyme, and (*b*) the oxidation of indigo white to indigo blue by the action of an oxidizing enzyme. He obtained these reactions in chloroform water which stops the activity of bacteria, but does not interfere with the action of enzymes (see article *Fermentation*).

The adequate treatment of the subject enzymes would naturally include a detailed account of the digestive enzymes and their action, but as this has already been given in the article *Digestion* in this handbook, it it will not be repeated here.

Relation of Enzymes to Serum Therapy and to Immunity.—There is no subject in the medical world at present which arouses greater interest than serum-therapy and immunity, and from the immense amount of work done in this field the following facts (among many others) are regarded as demonstrated:

(*a*) That the serum of certain animals destroys the red blood corpuscles of certain others (globulicidal action).

(*b*) That the serum of certain individuals has the power to destroy bacteria introduced into the system.

(*c*) That the blood (serum) of certain individuals has the power to destroy the toxic products of bacteria when injected into the system.

(*d*) The most potent factors in immunity from disease are (*b*) and (*c*)—especially (*b*).

The substances which confer this activity on blood serum have generally been regarded as proteid in nature, and these active proteids in (*b*) and (*c*) are commonly called "*defensive proteids.*" Two of the most prominent authors who have written on this subject are Buchner and Hankin. Buchner called these active substances *alexins*, while Hankin divided them into two classes: sozins and phylaxins, and these names are in general use at present.

Quite recently, in a series of articles in the *Münchener medicinische Wochenschrift* (1899 and 1900), Buchner has come out for the theory that his alexins are proteolytic enzymes, and he has advanced certain explanations of their action, involving the theory of immunity. Part of his theory has been disputed by Ehrlich, and an interesting discussion of the subject has followed, the details of which would be out of place here. It is interesting to note, however, that the increasing scope of zymolysis has extended to giving enzymes a possible place in this most advanced line of medical research.

George T. Kemp.

EOSOLATES are salts of sulpho-acids of the aliphatic creosote esters, representing twenty-five per cent. of creosote. *Calcium eosolate* $[Ca_3(C_9H_7S_2O_{12})_2]$ is a gray, gritty powder like pumice-stone, with a slightly pungent, rather ethereal odor, and a somewhat acrid and leathery taste. It is soluble in eight to ten parts of cold water, seven of hot water, slightly in alcohol and acetic acid, and freely in the presence of hydrochloric or citric acid. It is insoluble in chloroform or turpentine. H. Stern recommends it in dose of 0.25–0.7 gm. (gr. iv.–x.) three or four times a day for diabetes mellitus, diabetes insipidus, and phthisis. In larger dose it may cause diarrhœa and griping.

Eosolate of silver has been used in gonorrhœa, and *eosolate of quinine* in malaria and influenza.

W. A. Bastedo.

EPHEDRA ANTISYPHILITICA.—*Mountain Rush. Canutillo. Mormon Tea. Grease Wood. Whorehouse Tea.* The twigs of *Ephedra antisyphilitica* C. A. Meyer (fam. *Gnetaceæ*). This peculiar shrub, and various other species of the genus used similarly, are found in great abundance over the arid regions of our great plains. The plant reaches a height of two or three feet and produces a dense mass of erect, green, leafless branches, half the thickness of a lead-pencil and striate or channelled, with membranaceous scales at the joints. Wherever it is known, it bears a high repute in the treatment of venereal diseases, which are seldom differentiated in the reports. It is both bitter and astringent. The latter property might give it some value in gonorrhœa, while the former would render it tonic and perhaps alterative. No systematic study of its properties has been made, and we can only conclude that it probably has some merit. It is chiefly given in decoction; the dose employed representing one to two drachms of the drug. The remedy may also be administered in the form of a fluid extract. The drug contains a glucoside, *ephedrin*. *E. monostachye* L., of Asia, has a similar reputation.

Henry H. Rusby.

EPHEDRINE ($C_{10}H_{15}NO$).—An alkaloid derived from *Ephedra vulgaris* Rich. and *E. helvetica* C. A. Meyer. It is crystalline, colorless, and soluble in alcohol. It is used in the form of the hydrochloride, which is soluble in water. It is poisonous, resembling atropine in some respects. While it lowers the blood pressure, it causes the temperature to rise and the pupil to dilate. It is used like atropine for the latter purpose, one to two minims of the ten-per-cent. aqueous solution being instilled. It usually requires nearly an hour to obtain the desired effect, but when once obtained it usually lasts for from a half a day to one day, but accommodation is not affected.

Ephedrine, Pseudo-, has the same composition as the above and its hydrochloride has the same properties and is used in the same way.

Henry H. Rusby.

EPICARIN ($C_6H_3COOH.OH.CH_2.C_{10}H_6OH$) is a condensation product of creosotinic acid and beta-naphthol and is, chemically, oxynaphthyl-o-oxytoluylic acid. In its crude form it is a reddish powder, much used in veterinary practice, and called "Epicarinum veterinarium." From this, pure epicarin is obtained by recrystallizing from glacial acetic acid, and removing the excess of acetic acid by heating to 120° C. or by recrystallization from alcohol or benzol. It occurs in colorless or yellowish needles of a strong acid reaction, melts at 199° C., dissolves readily in alcohol and ether, and forms easily soluble neutral salts.

This remedy was introduced by Dreser as a non-toxic substitute for beta-naphthol, and was at once taken up by European dermatologists. Frick and Müller believe it to be slightly toxic, though others say it is harmless even to children. It is of especial value in scabies, for, though less destructive to the acarus than tar, lysol, carbolic acid, or creosote, it relieves the itching promptly, and is not unpleasant. Kaposi uses it in ten-per-cent. ointment, or in solution with alcohol and glycerin. He has had good results in certain eczemas, in scabies, prurigo, and herpes tonsurans. Pfeiffenberger rubs in every evening without preliminary bathing the following:

℞ Epicarin	7.5 gm.	(ʒ ij.)
Cret. prep.	2.0 "	(ʒ ss.)
Vaselin. alb.	30.0 "	(℥ i.)
Lanolin	15.0 "	(℥ ss.)
Adipis	45.0 "	(℥ iss.)

In his experience, epicarin is well borne by delicate skins; but, as the skin tends to become red and dry from continued use, he follows its application with diachylon ointment. In eczema pure and simple it does more harm than good. Some writers recommend epicarin highly in ringworm and other mycotic skin diseases. A good lotion would be:

℞ Epicarin	10.0 gm.	(ʒ iiss.)
Glycerin	10.0 "	(ʒ iiss.)
Tr. lavand.	30.0 "	(℥ i.)
Ether	30.0 "	(℥ i.)
Alcohol	ad 120.0 "	(℥ iv.)

For scabies the following is useful:

℞ Epicarin	15.0 gm.	(℥ ss.)
Sulphur	4.0 "	(ʒ i.)
Ungt. zinci oxidi	ad 90.0 "	(℥ iij.)

Sig: Rub in every second day.

W. A. Bastedo.

EPIDEMIOLOGY. See *Infectious Diseases.*

EPIDERMIN is made by mixing equal parts of melted white wax and powdered acacia, adding the same weight each of water and glycerin while boiling, and stirring until cold. It is used as a vehicle for skin medication.

W. A. Bastedo.

EPIDIDYMITIS. See *Testes, Diseases of.*

EPIGEA. See *Ericaceæ.*

EPILEPSY.—(Synonyms: *L'Epilepsie, Fallsucht, Epilepsia, Falling Sickness, Mal Caduceo, Morbus Herculeus.*)

Definition.—A disease in which sudden losses of consciousness are attended by more or less convulsive muscular action.

The seizures of epilepsy have been called—because of their varying degrees of severity—*epilepsia gravior*, or *grand mal*, and *epilepsia mitior*, or *petit mal*. The first is characterized usually by the severe attack, which consists ordinarily of marked loss of consciousness and complete violence of muscular movement; while the latter is manifested by a trifling seizure, with transitory mental obscuration and little or no muscular convulsion. There are irregular varieties which have been called *masked* or *aborted* epilepsy, owing to the imperfect development of the more familiar symptoms. In these masked cases the attack takes the form of a psychical derangement without definite motorial expression. An attack of this character is known as the "psychical equivalent" of an epileptic seizure. There are, besides these, a form known as *l'epilepsie partielle*, or hemi-epilepsy, which is always dependent upon cortical degeneration or unilateral disease, and another to which I have given the term *sensory*, in which more or less disturbance of the special senses exists with imperfect mental and motorial symptoms. A number of special names have been applied to epilepsies with reference to their etiology, "gastric epilepsy" being a familiar illustration.

The lighter form, or *petit mal*, may consist simply of a momentary loss of consciousness, during which the patient becomes suddenly very pale, while the color recedes from his lips and cheeks, and the respiration for the moment is temporarily arrested and then afterward accelerated. The eyes may remain open and be rolled upward; less often the lids are closed. While in the midst of some occupation the patient may be taken, and the particular act is interrupted in its performance. The glass or spoon drops from the hand, the pen is arrested in the middle of a half-written word, and oftentimes the patient's trouble is so transitory as to escape notice, he himself, as a rule, being utterly unconscious of it. Then afterward the sentence is finished, and, beyond an occasional residual dizziness, nothing remains to remind the patient of the attack.

In other cases, or at other times, the seizure is more grave, as regards both the unconsciousness and the severity and extent of the spasms. The patient may become rigid and then agitated by limited twitchings and cramps of the fingers. The color leaves the face, and the pupils are widely dilated. In a few seconds he is able to arise and go about his business. Delasiauve[1] and other French writers speak of *absences, vertiges* and *accès intermédiaires* as forms of petit mal, while Reynolds divides the light attacks into those without evident muscular spasm and those with spasm. The light attack may, according to writers generally, consist simply in an interruption of speech or the act of writing such as I have detailed; or of a sudden deviation of the eyes or head; or of a momentary confusion of ideas. The mouth is drawn to one side or the other, or widely opened, and there is a rapid alternate contraction of the muscles of the neck, so that the head executes movements backward and forward with great rapidity; or the chin is thrust forward and upward to one side, giving the individual the appearance of a person suffering from torticollis.

These attacks may simply consist in a temporary aphasia, the so-called *epileptic* aphasia, during which the patient is speechless or substitutes words.

The *petit mal* is either found alone, or the attacks occur in association with those of a more grave character. There are numerous cases in which light seizures alone exist, or for many years precede a more dramatic manifestation.

The fully developed attacks (*grand mal*) are frequently preceded by certain *warnings* or *auræ*, which may exist in a simple or complicated form. These, in their order of arrangement as regards frequency and constancy, are sensory, psychical, motorial.

The *sensory prodromes* of an attack are of the most diverse character, and the patient complains of such transient subjective sensations as tickling or tingling in the cutaneous surface, chiefly commencing in the extremities, on one or both sides, and centripetal in character, the morbid sensation appearing to advance toward the head from some distal point. This is a peculiarity of what is known as the *epigastric aura*, which consists of a very disagreeable sense of pressure beginning below the sternum and ascending. Patients complain of constriction of the throat, of a sensation as if ants were running or wind was blowing over the surface, of fugitive pains, and of a great number of sensory troubles. Certain visual warnings are complained of as immediate precursors of the attack. The epileptic is occasionally apprised of the coming on of an attack by the perception of colored rings, spots, or broad fields of color, in which red or blue most commonly predominates. Scintillation and *muscæ volitantes* constitute the auræ in some cases. The existence of these latter is of much shorter duration than the distal sensory warnings referred to above, and so sudden is their onset that the patient is frequently unable to describe them. Sometimes the optical illusion is likened to the recession of objects or their advance; or again, the patient alludes to his being environed by a cloud. It is by no means uncommon for patients to complain of double vision and of hemiopia, and, as a rule, this accompanies a grave form of the malady dependent upon coarse cerebral disease. There are sometimes auditory hallucinations, such as rushing sounds, the ringing of bells, or the whistling of the wind. In some instances the sound of the ordinary conversation carried on by the persons who are in the same room with the patient, may be greatly intensified in pitch. *Psychical warnings* of a more complex nature take the form of imaginary voices which speak imperatively or give commands; and in rare cases a visual hallucination is the immediate precursor. Foul odors, such as that of smoke or of ordure, or those of aromatic substances, are sometimes perceived by the epileptic. Vile tastes of nauseating substances are spoken of occasionally. In such cases the individual often carries his hand to his nose, or smacks his lips, or makes efforts at expectoration. Sensations of great heat or cold are mentioned (Champier, Delasiauve). Among the rare prodromes may be mentioned a desire to defecate, to urinate, or to vomit, and certain patients belch forth large quantities of gas. The patient in some cases talks unintelligibly or utters meaningless cries, occasionally with something like regularity in expression.

There are many premonitory *motor disturbances*, such as limited trembling of the small muscles, blepharospasm, or twitchings of the facial muscles or of the fingers. Some epileptics present automatic disorders of motility which are continued for some seconds.

The condition of the patient may be such, for several days preceding the attack, as to indicate impending trouble. There may be despondency of manner, listlessness, malaise, or a sense of danger ahead. The eyes are often injected, and the temporal vessels stand out rather prominently. There may, on the other hand, be a state of unusual vivacity or excitement, possibly headaches, tremor of the lips or tongue, and varied subjective disturbances, which in some cases are very peculiar.

Auræ are by no means constant; in fact, the majority of patients cannot give a satisfactory account of any special warning.

Of 519 cases collected by Delasiauve, of which 229 were personal, but half presented any history of auræ. Of the writer's cases, only 40 per cent. gave the history of anything that could be called a true and distinct prodromal symptom. Gowers' experience, based upon 1,000 cases, is that a special warning "was always absent in

495, while some aura existed, at least occasionally, in 505"; this is a very large showing.

The *major attack* consists of three stages, viz.: the stage of *tonic convulsion;* the stage of *clonic convulsions;* and the *stage of subsidence.* The first of these is much the shortest, and is sometimes merged in the second. The last stage includes the condition after the subsidence of convulsive movement; during this stage the patient regains consciousness or sinks into a more or less profound sleep.

The attack may or may not be preceded by a warning, but it generally is by some exclamation or cry. The *epileptic cry,* which is a purely psychic feature, is loud, shrill, and terrible, and may either be the result of an unconscious cerebral effort or the direct expression of fright. It lasts sometimes but a few seconds, and is rarely repeated before the actual *début* of the convulsion. In other cases the noise made by the patient is alone due to mechanical causes, the tonic spasm of the muscles of the thorax forcing the air suddenly through the unprepared vocal cords. A coarse, gurgling noise, of low pitch and short duration, is the result. Then we see the development of the seizure. The victim usually falls to the ground rigid and helpless. The fall is ordinarily backward, though sometimes he pitches forward or to one side, and this may be preceded by throwing upward of the arms. Sometimes the head is thrown back, the forearm and hands being rigidly flexed; and then more conspicuous appearances are beheld. When recumbent, the patient is in a position of pleurothotonos or opisthotonos, the body perhaps being laterally curved one way, while the head is drawn in the other direction. The eyes are usually widely opened, the whites of the eyeballs exposed, there being perhaps some tendency to conjugate deviation, or strabismus. The mouth is firmly closed or opened, or if the onset of the attack be sudden and severe, the tongue or lips may be caught between the teeth, oftentimes to their severe injury. The arms and legs may be extended very violently, the dorsal surfaces of the hands approximated, and the fingers flexed; the feet overlap each other, and the toes are often extended; the abdominal muscles are flatly contracted, and for a moment breathing seems to be suspended; the patient's face, which at first was momentarily pale, becomes livid, and the lips, ears, and finger nails show how imperfect is the decarbonization of the blood; the skin of the hands is purplish, wrinkled, and cold, and all about the mouth is a dusky ring fading off to white at the points where pressure is made against the teeth.

The rigidity is so great that, if there be time to make such a test, it will be found that the exhibition of ordinary force will not enable the observer to overcome the extension. According to Mercier, who studied the disease very closely in an interesting case, "the rigidity is greatest in the hands, less in the wrists, still less in the elbows, and not very great in the shoulders. It is less in the legs than in the arms or neck; the head being retracted with a force approximating to that which immobilizes the elbows." The inequality of this rigidity, which may sometimes be unilateral, suggests certain structural cerebral defects, either due to previous disease, or to hemiatrophy, or to traumatism. Sometimes the mouth is drawn to one side, the head being turned to the other; this result is due to the fact that the cramp of the muscles of one side is distinctly more pronounced than that of the muscles of the other side. The pupils are now found to be widely dilated, insensitive to light and touch. The face becomes engorged, and with such a change the breathing is noisy and rapid. The lips flap loosely with each inspiration and expiration, churning the froth, which is perhaps tinged with the blood that may come from a wounded tongue. As Mercier has observed in his case, the spasm of the oral muscles may be synchronous with the respiratory movements. The movements of a clonic nature now occur, and these may be more or less violent. There is little regularity in their happening, though I find it the rule for a succession of jactitations to mark the discharge emanating from fresh groups of cortical cells; the spasms in one extremity disappearing as those in another extremity become more prominent. The spasms, as a rule, are disorderly, and in no sense rhythmical. There is in some cases a fine tremor which is more or less pronounced, and this takes the place of active spasm. Mercier observed a patient in whom the tremor began in the periphery and spread toward the trunk. The clonic spasms of the upper extremities consist sometimes of alternate pronation or supination, flexion and extension of the hands, the thumbs being doubled under the fingers, which are strongly flexed. The movements which, as a rule, affect the extremities at first, finally become so general that the trunk is involved, and a diversified number of contortions take place, the pelvic movements being very marked. These clonic convulsions are so severe that the patient very often throws himself from the bed upon which he may be lying, and in severe cases it requires the exhibition of much force to keep him from injuring himself. This stage continues for a variable time, which usually seems much longer than it really is. There may be a fresh accession of clonic spasms, but ordinarily the attack is short-lived, and the person gradually becomes more quiet; the color returns to the face; there are some signs of subsidence, for the breathing grows regular and perhaps sighing; the pulse is more regular and less full, the rigidity disappears, and the subject makes movements, especially of the mouth, which are semi-volitional. The head may now be rolled uneasily from side to side, and some effort to arise may be attempted. The patient may open his eyes and look vacantly about, or murmur indistinctly. Sometimes the confusion of ideas which attends the glimmering return to consciousness may manifest itself in incoherent talk and transposition of words.

During the convulsive stages the patient often has involuntary discharges from his bowels or bladder, and it happens that seminal emissions even may occur. This is true especially of the nocturnal attacks, and is often a valuable diagnostic point to observe, and in adults nocturnal incontinence of urine often exists with unsuspected epilepsy.

The cutaneous reflexes are lost during the attack, but after the subsidence of the clonic stage we find that there is a return, and that the deep reflexes are very much exaggerated, this being particularly true, in some cases, of the ankle clonus. In one instance, elsewhere reported, I found that an epirotulian blow would produce a response in the opposite leg. The patient gradually regains his normal state and arises, or more commonly he sinks into a deep slumber, from which he awakens exhausted and with headache.

The *temperature* and *pulse* of the epileptic undergo very important changes. In the status epilepticus there may be a decided increase of the former, but during the attack there are but slight variations. The pulse is quite thread-like, especially during the first stage; while during the stage of clonic convulsion it is much more full and rapid.

The *urine* passed after the attack is found to contain urea and the phosphates in increased amount, indican, and occasionally albumin. Huppert holds that the presence of the latter is constant, and I am fully able to confirm his statement. Herter and Smith found that there is often a change in the proportion of sulphates in the urine, the ethereal sulphates being increased to an excessive degree.

Immediate Results of the Attack.—After the attack we sometimes find a variety of disturbances of the nervous system. These are exceedingly variable, and may consist of sensorial or motorial manifestations, and in the former I include the immediate mental derangement. I have already alluded to the headache, which is dull and vertical or frontal. Of course the injuries the patient may have sustained are quite apt to leave behind their painful effects, but there are disturbances which are connected with the fit itself which are exceedingly annoying. Excessive muscular violence may give rise to fibrillary rupture, and, in rare cases, to dislocation of the large bones.

Spots of cutaneous anæsthesia are complained of sometimes, and the skin is covered with petechiæ.

The post-epileptic mental state has been studied by Jackson, and is of especial interest in light or imperfectly developed attacks. The aphasic state has been spoken of, and I will add only that, when there is a disturbance of speech of appreciable duration, the beginning of recovery is marked by the use, first, of words containing vowel sounds, and then only later of those containing consonants. This fact was first observed by Jackson and formulated in his rule—that simple and quasi-automatic processes suffer least, and are soonest recovered, while complex arrangements suffer most, and are more tardily recovered from. The post-mental state is often expressed by peculiarities in the behavior of the individual, by automatism, and occasionally by violence or the commission of purposeless acts. The patient may be dull, forgetful, or slow in all he does or says. Sometimes, however, the attack acts as an apparent vent, for the epileptic who is dull before the paroxysm is afterward exceptionally bright. In certain cases a blunting of the moral sense, with impulsive promptings, is shown in the performance of various mischievous and dangerous acts.

The motor disturbances are chiefly paralysis and subsidiary spasm. A condition known as post-epileptic paralysis is an occasional sequence of hemi-epilepsy, and may last for some time. In some instances there may be simply a loss of power, which is present for a few hours or days, while in others the paralysis is permanent, and perhaps is indicative of the commencement of widespread coarse cerebral disease. In some cases, subsequently to the attack, convulsions may begin in the paralyzed members. In still other cases, although rarely, a vesical weakness may follow an unusually severe attack, or, as a result, a peripheral paralysis may follow the injury of some nerve trunk, either in connection with dislocation or as a result of violence connected with the patient's fall. Some diagnostic interest is connected with these cases.

Remote Effects of Epilepsy.—The epileptic whose disease is deep-seated presents certain conspicuous indications of his disorder. His expression is dull, the eyes lacking lustre, and the lines of his face are by no means well marked. His facial muscles may be the seat of a low grade of paresis, or an hemiatrophy may give rise to an easily recognizable asymmetry. Fibrillary tremors are by no means uncommon, and the lips are puffed and rather inclined to present a purplish tinge. Acne is common, even when bromides are not used to excess, and the tongue often presents old scars, the evidence of former attacks. The patient's movements are not characterized by vigor. Mentally he may present evidences of great weakness, especially if the form of attack has been that of the petit mal, but it does not follow that epilepsy should bring in its train any decided degeneration of this nature. Many epileptics who have occasional grave attacks preserve their original strength of intellect. There are many epileptics whose paroxysms are purely the expressions of the insane neurosis, and this is true especially of children with deformed crania and irregular teeth, and who are imbeciles or idiots. These subjects are, perhaps, able in a weak way to perform acts requiring little intellectual energy, or they grow up presenting characteristics which are overlooked by fond parents. The "strange" child does unlooked-for things, is vicious, or unduly mischievous; applies itself to certain studies, learning with great ease, while it is hopelessly deficient in others. Such a child may display exceptional smartness in mastering some limited "accomplishment." Born of drunken or insane parents, at ten it becomes epileptic. Its "queerness" increases, and its fits are not cured; dementia follows, or the type of disease changes, and the infantile attacks are substituted by epileptic insanity; the latter developing, if the subject is a female, in connection with some menstrual derangement, or a trying pregnancy, or at the menopause.

Epileptic attacks may be divided into three classes as regards their time of occurrence—*matutinal, diurnal,* and *nocturnal.* The mode of occurrence may be regular or irregular. So far as my experience goes, the greatest number of severe attacks occur in the early morning, or during the night, while attacks of petit mal may occur alone during the day. The attacks may be very numerous, several hundred perhaps occurring within the twenty-four hours. Axenfeld reports a case in which one hundred and fifty occurred in one day, and Newingham another in which no less than six hundred and twenty-two convulsions were counted in the same time. Such cases are, of course, very unusual. In point of rarity, I have had several patients who have had well-defined attacks as far apart as two years; and one gentleman comes to me almost yearly to report that he has had one or two attacks within one week after an interval of many months. By far the greater number of patients have attacks every two or three weeks, and women have them chiefly at the catamenial period, or shortly afterward. Of course, if the disease becomes established the intervals become shorter, and in hospitals for the epileptics the case-books show that most of the patients have from one to a dozen attacks daily. Attacks of petit mal, when the disease is well established, are of course much more frequent.

There is a tendency in epileptic attacks to occur in groups. Isolated attacks, as Gowers very properly says, are more common, and when the attacks occur in cycles there is little regularity, so far as number is concerned.

Young children are very apt to have one or two convulsions, which are looked upon simply as eclamptic, and and then they remain entirely free from any return until the eighth or tenth year, when several entirely unexpected seizures make their appearance. In many cases there is no antecedent history of trouble, but, without any cause whatever, one or more paroxysms appear. The possibility of further trouble keeps the patient's friends in a state of doubt and uncertainty.

The risk of a second attack within one month is considerable, and such risk does not disappear for a long time. Too great caution cannot be exercised as regards the giving of an opinion, and while it will not do to say that all early eclamptic attacks are suggestive of subsequent epilepsy, it is a fact that the early spasms of childhood, occurring perhaps at the third or fourth year, between the periods of the first and second dentition, are quite likely to be the precursors of others in regard to the character of which there can be no possible doubt.

The *status epilepticus* is a condition which marks the occurrence of a great number of attacks, and when consciousness does not return between them, the patient becomes increasingly comatose, the body-temperature rises to a considerable height (105° to 107° F.), and death soon follows. Recovery, however, is not impossible.

Sensory Epilepsy.—Under the caption of "thalamic epilepsy," Dr. William A. Hammond[2] described a form of the disease in which sensory disturbances predominated, and which he believed to be due to a lesion of the optic thalamus. The attacks, which belong to nothing more nor less than a sensory epilepsy,[3] are characterized by a few or no disorders of motility, but by the occurrence of hallucinations of a more or less elaborate character, and by hemiopia. With these are commonly associated some headache of a migrainous type, and occasionally anæsthesia, or the loss of the volitional power of speech. Jackson,[4] in his earlier articles, freely and fully explains the pathology of various sensory auræ and minor attacks. The symptoms which I have observed in these cases all belonged to Exner's third group of hallucinations of sight (*Gesichtshallucinationen*)[5] and are undoubtedly of cortical and not of thalamic origin.

The lack of space will not allow me to give an account of more than one case of the kind which has just been under discussion. The details, in brief, are as follows:

Miss J. D——, aged 29, comes of a neurotic stock; a brother and sister both suffer from incomplete epilepsy, and her mother has had headache and incident hystero-epilepsy. The maternal grandfather was extremely eccentric, and possibly insane, and there are other instances of neurotic disease in the family history.

Since her early childhood she has suffered from vertigo and headache, and at the commencement of menstruation she became hysterical. She is at present a healthy-looking woman, somewhat nervous and excitable in manner, but clever, intelligent, and possessing an unusual memory. Her present attacks became quite marked three or four years ago, and during the past eighteen months they have occurred every three or four weeks—without any apparent relation to menstruation. Occupation and excitement alone seem to possess the power of diminishing the frequency of their recurrence.

As the first symptom of any disturbance of her vision she noticed a unilateral dimness of sight, and afterward a blindness which was sudden and absolute; she invariably "lost half of the object at which she was looking." Her first attack of this kind was in a railway station, and while looking at the clock the figures from "XII." to "VI." disappeared. This partial abolition of sight lasted for a period of ten or fifteen minutes, and shortly after its occurrence she noticed a numbness of the tongue, and pain on the left side. This numbness next appeared in the fingers of the left hand and slowly extended up to the elbow, when it stopped. The right hand next became involved, and after a "furry feeling" of the tips of the thumb and forefinger her hand became "dead and without feeling" as far as the wrist. From five to fifteen minutes after this had occurred she lost consciousness, and while in this unconscious state she made quasi-convulsive movements which were undoubtedly psychical, as she rubbed the hands over each other, and made attempts to remove her rings. She stated that her fingers were swollen, and that considerable difficulty was experienced in removing the rings from her fingers. (Her sister corroborated this statement.)

As regards the subsequent attacks, the patient states that two or three minutes after the development of the anæsthesia there is often exquisite pain over the right eye, which augments in severity and extends over the entire head. This lasts sometimes for an hour or so after the attack, and is not relieved by any application.

During the unconsciousness, which is complete, she neither breathes stertorously, nor bites her tongue, nor shows any epileptic appearance, except it may perhaps be a slight pallor and dilatation of the pupils. It is impossible to arouse her for several minutes. The attacks are often aborted by strong mental effort, or by diffusible stimulants. Upon several occasions she has been suddenly deprived of the power of speech, and could not express herself, but this is exceptional. Such mutism was coincident with the hemiopic stage, and did not develop subsequently to the loss of consciousness.

At the time when she first consulted me she had neither menstrual nor other disturbance of the pelvic organs. She slept soundly, and had dreams nearly every night, but she was not a somnambulist. After the attacks she passed large quantities of clear urine. There was no color blindness.

Physical examination revealed almost nothing except it may perhaps be a suspicious bulging of the left optic disc, and a tortuous and enlarged condition of the veins. The tongue pointed slightly to the right.

Masked Epilepsy.—There are many forms of irregular seizures which present interesting features. In some there may be a few of the ordinary manifestations of the familiar attack in association with others which are quite bizarre. In several cases which have come under my observation the patients began to run violently about the room, and finally became convulsed. In others the whole attack consisted in continued running, the subject being unconscious throughout. In two or three patients there was a tendency to remove all their clothing, without the least appreciation of what they were doing. A form of the disease in which the epileptic remains in a species of trance is occasionally presented. Sometimes the attack will take place without attracting attention. I have recently had under my care a clergyman who wandered in an aimless sort of way about the country, and when afterward found could give no account of himself for the week previous to his discovery. While in this dual state the patient will get into altercations with strangers, or commit purposeless acts. Such cases are of great interest from the standpoint of medical jurisprudence. As a rule, the reprehensible acts are motiveless, and are not remembered after commission.

The *interparoxysmal state* may be one free from any nervous trouble whatever, the patient remaining perfectly well until a new explosion takes place. At other times, on the approach of the paroxysm, there will be a change in the patient's manner which betrays itself in an apprehensive melancholy, that may still later give way to a condition of great irritability. Occasionally an aphonia may exist during the entire interparoxysmal period, but this is rare. Romberg speaks of dysphagia, tympanites, trismus, and ischuria as possible sequelæ, which may last a long time. Romberg believes that epileptic individuals are less likely to contract contagious diseases, but, as Axenfeld very properly says, these observations lack sufficient proof. The pupils during the interparoxysmal period are, as a rule, very mobile, and act too readily to light stimulation. The pulse during the interparoxysmal state is usually soft, slow, and compressible; the cutaneous circulation, especially in old epileptics, is poor, and the hands are inclined to be livid and dry. Hang-nails and other evidences of malnutrition are quite common.

The influence of pregnancy has been the subject of much controversy. The burden of proof goes to show that epilepsy does not interfere with the process of gestation in any serious way, and, as a rule, does not induce miscarriage. Pregnancy, on the other hand, seems to aggravate the epileptic state itself, though quite exceptional cases are reported in which a cure was effected through the establishment of this condition. Such cases are mentioned by Landre, Beauvais, and Delasiauve. Suppression of the menstrual flow is apt to precipitate the convulsions.

In certain rare cases the course of epilepsy is greatly modified, if not cured, by the occurrence of one of the eruptive fevers. Minor attacks may be transformed into major through the agency of an illness which may, perhaps, be of this character.

ETIOLOGY.—It is an undeniable fact that heredity plays the most extensive part in the causation of epilepsy. Of the 980 cases no less than 435 presented some family history of neurotic or pulmonary trouble.* Thirty-five per cent. of Gowers' cases were characterized by the same state of things, and with other authors—among them Reynolds and Echeverria—the proportion of cases in which there is a neurotic inheritance varies from thirty-five to forty per cent. As the result of such inheritance we find that female cases rather preponderate. Of very young subjects this is the rule, but when the disease begins after twenty it appears that there are more males who become epileptic than females. In the greater part of all cases the disease first manifests itself before the twentieth year.

Of 980 collected cases in which the beginning of the disease was known, there were—

	Females.	Males.	Total.
Under ten years	103	95	198
Between ten and twenty years	171	97	268
Between twenty and thirty years	145	92	237
Between thirty and fifty years	81	136	217
Over fifty years	11	49	60
Total	511	469	980

Cranial deformities, especially microcephalus, are found with epilepsy, and children whose crania have undergone pre-ossification are quite apt to suffer from irregular forms of epilepsy. Ten or fifteen per cent. of children, according to Delasiauve, present epilepsy conjointly with idiocy. The convulsions are quite apt to be associated with some curious form of intellectual perversion.

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* Drunkenness included.

The *traumatic causation* of the disease is exceedingly interesting, because of the occasional strange character of the injuries. As a rule, blows which leave only slight or no external signs of their violence are apt, after the lapse of years, to be followed by the outburst of epilepsy. Depressions over the paracentral lobes may be found in connection with unilateral paroxysms. Bullet wounds which perhaps have caused extensive erosion of bone may also be mentioned as causes. In one case, for example, the patient presented a large excavation in the petrous and mastoid portions of the temporal bone, and this wound, which had excited a meningeal inflammation, also gave rise to a very severe epilepsy with maniacal outbursts. Blows producing fracture of the internal table of the skull frequently account for the disease. A scar left from a head injury may be the starting-point of a painful aura which is the precursor of an attack, and various writers allude to injury of the nerve trunks, the sciatic especially, as an important though rare factor.

Syphilis, in either its secondary or its tertiary stages, but more often in the latter, may give origin to an epilepsy of a peculiar type. The seizure, as a rule, is preceded by headache, and is often associated with other neurotic changes and monoplegiæ. The interparoxysmal state is quite apt to be characterized by more or less loss of memory, intellectual weakness, and, in some cases, a great desire to sleep at odd times and places, such a tendency being apparently irresistible. In many cases there is disease of the cranial bones as an intermediate factor.

Fournier says that when epilepsy manifests itself for the first time in a patient of twenty or thirty it is of specific origin in eight or nine cases out of ten.

The *exanthemata* may be followed by the development of epileptic attacks which are often very intractable. Especially true is this when it is scarlet fever that has preceded the paroxysms. Not only may this disease have such an influence, but measles, smallpox, diphtheria, and a number of maladies of like nature, may directly cause the epilepsy.

Metallic poisoning is a rare cause, and when we find epileptic convulsions in such cases it is usually symptomatic of some advanced encephalopathy. The use of absinthe and alcohol, when excessive, is quite apt to give rise to convulsions, which are usually of a violent type. The latter, as a rule, are imperfectly formed, and the loss of consciousness is peculiar. In some the mental derangement is of the nature of a trance, and the patient's seizures resemble the form of the disease known as "masked epilepsy."

Malarial poisoning may underlie an epilepsy which is seemingly periodic and attended by great rise of temperature; it may be cured by large doses of quinine.

In certain cases *great* and *repeated losses of blood* will give rise to epilepsy. In some cases there is an initial migraine, which exists for some time before the occurrence of the seizures. *Sunstroke* occasionally is the exciting cause of a series of convulsions, which, however, can rarely be called epileptic.

It is not uncommon for an epilepsy to develop at the time when the menstrual function is established. Herpin reports the case of a girl whose convulsions appeared at the menstrual epoch, and recurred with each succeeding period; Maisonneuve reports similar cases. The suppression of vaginal fluxes is naturally a determining etiological influence.

Sexual excesses are too often supposed to give rise to epilepsy, and masturbation especially is given great prominence as a cause. Onanism is very common among epileptics of low moral gauge, with physical anomalies of development, but it can hardly be considered in the light of a cause. Excessive copulation and lustful excesses are mentioned by Continental writers as playing a part in the creation of the disease.

Of *fear* and *mental worry* and *anxiety*, many authors are disposed to speak as important exciting or predisposing causes. There is no doubt of the bad influence of the latter, but the importance of the former is to be admitted with some reluctance, although it cannot be denied that a sudden shock or fright has caused attacks.

Various exciting causes are quite likely to be discovered, especially among young subjects. Many so-called eclamptic, or rather epileptic, seizures are caused by *intestinal worms*, or by the presence of undigested food and the absorption of ptomaïns.

Intestinal worms, while they are often responsible for infantile eclampsia, rarely produce epilepsy in adults. Luykx and Michel report cases in which the disease seemed to be dependent on tænia, and in that reported by Michel the seizures occurred during five years, and ceased with the expulsion of the worm.

Muscroft[7] reports a case of stone in the bladder which gave rise to epileptic convulsions. The successful removal of the stone effected a cure of the epilepsy.

Irritation of the auditory apparatus is likely to produce epilepsy, and the paroxysms may follow such simple excitation as blowing into the ear. The attacks from such a cause may even be very violent and general.

So far as the influence of diet is concerned, we find that continued or excessive indulgence in animal food is likely to predispose to the disease in some persons. Many first attacks may be dated back to an engorgement of the stomach or to some act of gluttony, and in many cases immoderate indulgence in food often constitutes an exciting factor. Portal speaks of several subjects who became epileptic after gluttonous indulgence in beans (Delasiauve), and the older writers also refer to cases in which the ingestion of poisonous fungi or of ergot has been the assigned cause.

MORBID ANATOMY AND PATHOLOGY.—There is nothing that can be called constant or characteristic in the way of a morbid anatomical appearance in the epileptic brain. This disease has existed in connection with almost every variety of pathological change. Meningeal or osseous thickening, exostoses, vascular dilatation and sclerosis, cerebral atrophy and hypertrophy, the presence of tumors—all these lesions have been found to exist in epileptic cases. Epilepsy is found among children whose sutures have closed prematurely, and I have seen a number of such cases in which the fits have appeared between the fifth and tenth years—which is due, as I suppose, to the fact that the brain rapidly develops at the fifth year, but, owing to preossification, and the resulting limitation of the space afforded by the cranial cavity, this organ is denied sufficient room for expansion. In traumatic cases we find all varieties of fracture and depression, and occasionally the existence of old subdural cysts.

Lunier[8] found that the crania of many epileptics presented various abnormalities. In some he found a flatness or depression of the frontal bone; in other cases an asymmetry between the lateral halves of the skull, which was the result of undue prominence of the parietal bone of one side. Lasègue called attention to a fronto-facial asymmetry which was the result of a consolidation of the sutures at the base of the skull, the union being a slow one, and usually requiring for its accomplishment the space of eighteen years, at the end of which period the attacks would appear. The cerebral deformity resulting from this asymmetry consisted in an inequality in the size of the two frontal lobes, the depression being most often noticed upon the right side (Axenfeld). Certain facial peculiarities, as well as deformities of the vault of the palate, were associated with this.

Echeverria,[9] Van der Kolk,[10] Luys and Voisin,[11] and others, have observed morbid appearances in the medulla: the presence of amylaceous cells, an exudation of a granulo-albuminous nature, cell degeneration and pigmentation, as well as destruction, in part, of certain important nuclei, notably of the hypoglossus and pneumogastric nerves. Echeverria found lesions of that portion of the great sympathetic which is located in the neck.

Ogle and Jackson have reported many cases in which there was cortical degeneration, especially of the paracentral lobule. In cases in which dementia or other mental troubles are found, and especially in those in which the mental disturbance takes the form of general paresis, we may expect to find a well-diffused cortical sclerosis.

Some years ago Delasiauve, Bouchet and Cazauvieihl, Meynert, Sommers, Bourneville, and others, found in many epileptic brains a peculiar induration of the cornu ammonis, which they regarded as peculiar to epilepsy. I have repeatedly found this appearance, and certainly it is worthy of consideration, though it cannot be regarded as pathognomonic. Sommers found this induration in thirty per cent. of his cases, while Bourneville found it in only seventeen per cent. The other authors whom I have mentioned regard it as an almost constant lesion. Kussmaul and Nothnagel, on the other hand, disbelieve in the importance of this lesion.

Epilepsy has been experimentally produced in various ways. Kussmaul and Tenner, Astley Cooper, and others, have by ligation and compression of the carotid, given rise to seizures which disappeared when the constriction was removed. Other experimenters have, by ligation of the superior and inferior venæ cavæ in animals, obtained the same result.

Nothnagel found that by tapping the heads of guinea-pigs an epilepsy was established, and various mechanical means of jarring the cerebral contents have been devised for the experimental production of epileptic convulsions.

The theory enunciated by Brown-Séquard was, in effect, that epilepsies might be provoked by irritation of certain sections of the cord in the lumbar region; that injury of the sciatic in certain animals (guinea-pigs chiefly) would give rise to convulsions; that the progeny of animals thus mutilated were the possessors of certain so-called epileptiginous zones, which, when irritated, would give rise to genuine epileptic paroxysms. These epileptiginous zones were located about the face and neck, and irritation, especially of certain branches of the fifth—the suboccipital chiefly—would produce the fit. In man such zones are, as a rule, not to be found.

Injury of the medulla oblongata has been followed by epilepsy, and electrical or mechanical irritation of the cortex cerebri, cerebral peduncles, or restiform bodies produces the same effect.

Finally, experiments have been made with certain toxic agents, among them alcohol and absinthe. Poulet found, for example, that the subcutaneous injection of the salts of ammonia gave rise to epilepsy.

The existence of epilepsy depends, undoubtedly, upon an instability of the cellular elements, and when a lesion exists it is, as Jackson has shown, undoubtedly of an "irritative" character. The starting-point of the convulsion is probably primarily in the cortex cerebri, and secondarily in the medulla. The view of Van der Kolk, which has been accepted with modifications by Reynolds and others, is that the focus of the disease is in the medulla oblongata. In the established form of epilepsy this centre is in a condition of excitability, and through the receipt of reflex impressions, either from higher parts of the cerebrum or from the periphery, an altered inhibitory vascular state ensues, the parts lying at the floor of the fourth ventricle become the seat of hyperæmia, and then follow various pathological changes, viz., a secondary anæmia and hyperæmia of the cerebrum, and irritation of convulsive centres. As a result of these pathological changes there will be tonic and clonic convulsions of muscles supplied by the nuclei of the lower cranial nerves, with consequential disturbances in the domain of the spinal accessory and other nerves. Spasms of muscles of the neck, asphyxia, compression of jugulars, secondary stupor, tongue biting, etc., are among the phenomena observed in these cases. Van der Kolk believes that the biting of the tongue is due to irritation of the nucleus of the hypoglossus.

Diagnosis.—The diagnosis of the ordinary epileptic attack is not a difficult matter. The seizure is of such a dramatic and pronounced character that it is scarcely possible to err in regard to its true nature. The minor seizures are sometimes confounded with attacks of syncope, but when we exclude the disorders of motility, which do not belong to the latter, there should be no chance for mistake. It must be remembered that seizures of petit mal do not occur in an isolated form, but that there is a history of numerous previous attacks.

It is important to diagnose whether or not the paroxysm is the manifestation of coarse disease of the brain; and, in such cases, limited or rather extensive paralysis will often be found, as well as optic-nerve atrophy, disturbed reflexes, and distal sensory trouble.

Hysterical epilepsy is, as a rule, a complaint of women, and the attacks seem to bear some relation to the occurrence of the menses. Charcot speaks of the hysterical modifications of epilepsy as follows: 1. A form in which hysteria is engrafted upon primary epilepsy. 2. A form of primary epilepsy which is complicated after marriage by hysteria. The hysterical influence is destroyed by pregnancy. 3. Primary hysteria with superadded epilepsy at a later date. 4. Convulsive hysteria with coexistent petit mal. 5. An epileptic attack with residual hysterical contraction and hemianæsthesia.

I have observed another form, viz., that in which an epileptic patient was seized with hystero-epileptic paroxysms at the menstrual period.

In some instances the diagnosis must be made between the grand attack and the convulsions of *uræmia* or *alcoholism.* The uræmic convulsion is usually preceded by a history of mental obscuration with perhaps some ataxic aphasia and headache. The presence of œdema, albuminous urine, casts, and the skin pallor, furnish confirmatory indications.

The alcoholic convulsions, unless due to chronic alcoholism, are preceded by a debauch. If the urine be examined it will be found that the bichromate of potash test will reveal the presence of alcohol by a very peculiar and striking change of color to green.

Sometimes we may confuse the lighter attacks with auditory vertigo, or with lithæmic or gastric vertigo, but the rotary character of the disturbance in the former, and the connection of the latter with digestive disturbance, are to be borne in mind.

It is of the utmost importance that the medical man, especially if he be called upon to treat and inspect soldiers, prisoners, or the inmates of the pauper asylums, should be on his guard in regard to the simulation of epilepsy. This form of imposture is common enough, and is very difficult of detection. Various authors upon medical jurisprudence have recorded a number of cases in which a malingerer kept up the deception for a period of several years. The case of "Clegg, the Dummy Chucker," reported by Carlos MacDonald, is of this kind. The subject was an habitual criminal who repeatedly threw himself from high platforms in the jail to the stone floor below, and bore many self-inflicted injuries without a murmur, that he might escape certain duties or punishments. He was finally detected by MacDonald. The impostor cannot change the size of his pupils, nor can he counterfeit the color of the skin which belongs to the real fit. The epileptic, as a rule, doubles his thumb under his other fingers, which are strongly flexed—a thing neglected by the impostor. The latter is ordinarily on the alert to see how his behavior will impress the bystander, and an occasional suggestion from an outsider will be acted upon by the designing person, who will thus betray his consciousness as well as his anxiety to make an impression.

Prognosis.—Epilepsy is certainly one of the most discouraging of all diseases of the nervous system so far as the hope of cure is concerned, but the prognosis is much less bad at the present time than it was before the introduction of the bromides. Those forms of epilepsy which are of idiopathic origin, or which are dependent upon coarse cerebral disease, osseous lesions, or advanced syphilis, are wellnigh hopeless, but of those cases which owe their genesis to less profound causes, a few are modified or cured by treatment. It is impossible to give satisfactory statistics of cures, from the fact that most of the cases are imperfectly watched. Sex seems to have little or nothing to do with the patient's chances. The cases in which the disease develops before the tenth year, or after adolescence, are more readily helped than those in which it begins between the tenth and twentieth years (Gowers); and this is probably due to the fact that the idiopathic causation is more common before twenty. The form with grave attacks alone is more easily cured than that in which petit mal is a feature;—and uncomplicated petit mal is perhaps the least hopeful of any form. The curability of the disease depends much upon its duration and the number of attacks, and one author believes that all cases in which five hundred attacks have occurred are absolutely beyond the reach of any treatment. Cases of hereditary origin are commonly regarded as the least amenable, but Gowers is not of this opinion. Fifteen per cent. of Gowers' successful cases were those in which heredity existed. My own experience does not confirm this. Those cases in which the fits are separated by long intervals are most readily cured, but if the attacks be severe and if they recur at short intervals, the prospects of a cure are poor. Attacks which seem to be connected with disordered menstrual function are sometimes very readily abolished. The existence of an aura renders prognosis slightly more unfavorable, although in some instances the aura enables the patient to abort the fits. Cases in which cranial deformities exist are usually bad, and the attacks are irregular and eccentric. The existence of mental impairment or aberration of any kind is always unfavorable.

Fatal cases—that is, cases in which the patient's death has been directly due to the disease—are rare. When death occurs, we find that asphyxia is usually the immediate cause. It occasionally happens that epileptics are suffocated from the lodgment of a piece of meat in the air passages, while a number of accidents, among them falls, are apt to lead to death by drowning, by cranial fracture, or by suffocation caused by the unnatural position in which the patient's head has been placed as a result of the fall. In several instances of which I know, the patients fell into an open fire-place or against a hot stove. I have already alluded to the danger of rupturing a muscle or dislocating a joint. Another rare accident is the amputation of the tongue that may occur when it happens to get between the teeth.

According to Axenfeld and other French writers, the complication of epilepsy with hysteria is one calculated favorably to modify the prognosis of the former.

TREATMENT.—In our management of epilepsy, we are to avoid everything that smacks of routine treatment. The mere administration of a much recommended drug, without studying the indications for its use, will do little or no good. The epileptic paroxysm, after all, is but a discharge from over-excited and unstable nerve cells, and is a symptomatic condition of a great variety of pathological states. As a general plan of treatment it should be the earnest of our endeavors to maintain a condition of circulatory equilibrium, so that the cerebral blood pressure shall not undergo very rapid, sudden, or great changes. Cardiac stimulants or sedatives should, perhaps, form a part of the treatment in different cases, and these may be combined with remedies having specific neurotic or alterative effects. In some cases the use of digitalis is almost a necessity, and in others—those more particularly in which there is a tendency to cerebral hyperæmia—remedies of an opposite class are required. In what the older writers called anæmic epilepsy, the use of digitalis is absolutely important, or we may use a remedy which was first recommended by the writer a few years ago, viz., nitroglycerin, in doses of gr. $\frac{1}{100}$ to $\frac{1}{25}$ thrice daily.

There are a great number of remedies which have been used empirically almost from time immemorial. In many cases no intelligent idea is entertained as to their physiological action. It is not proposed to refer to many of them, except in the most superficial way, or not at all, for but few possess any virtues.

No general remedies have been of so much service as the bromides, especially those of sodium, ammonium, and potassium, and since their introduction, about twenty years ago, the number of cures has greatly increased. The prognosis has also improved, as our knowledge derived from experimental therapeutics has broadened. In 1865–70, five or ten grains of the bromide of potassium in divided doses was considered a maximum quantity, but already a few years later certain American physicians advocated immense doses—even an ounce daily. Maximum doses of twenty grains, repeated thrice daily, control the convulsions in cases which are amenable to treatment,—cases in which the attack has perhaps been previously aggravated by very large doses.

In most cases of this grave disease it is of the first importance to ascertain the length of the intervals between the attacks, the time of day at which they usually occur, and the patient's general condition. The amount of bromide to be given daily, say of the sodic salt, which is the best, may be fixed at from one to two drachms, to be given in divided doses, the largest one just before the expected attack. Should the latter occur in the early morning, it is best to administer the remedy at night, and perhaps to reinforce the quantity. In some cases in which the periodicity of the paroxysm can be definitely determined the dose may be increased, and the drug used more freely for several days before the expected explosion. Many practitioners commence by inducing a mild brominism, which is manifested by anæsthesia of the fauces, and by some appearance of acne upon the forehead, or by the bromic breath. It is exceedingly injudicious to go beyond this point, for when the nutritive processes are interfered with, the medicine does harm instead of good. The bromic salts should always be given in plenty of water, and Vichy is a decided improvement over simple water, because of its advantage in securing tolerance of the drug by the stomach. When epilepsy is dependent upon organic changes, either syphilitic or otherwise, a saturated solution of the iodide of potassium or sodium may be used separately and either of these salts given in milk, or Vichy should be used in large quantities. The so-called "American System" should be followed, in the administration of the iodide, and even half an ounce or more should be given daily. In cases in which the attack is preceded by headache, the iodide is especially serviceable. The bromides may be given in combination with tincture or infusion of digitalis, and small quantities of arsenic may be incorporated for the purpose of preventing skin troubles. In other cases the combination of chloral hydrate or aconite is advisable. The bromic treatment should be continued in a modified form for at least two or three years after the attacks disappear. It will be found, in some cases, that the combination of the three principal bromides sometimes acts more energetically and efficaciously than either singly. The use of fats, especially cod-liver oil, is often of the greatest service when the bromides fail alone. I have been enabled in this way to help many cases in which the bromides had been used before without any considerable success. The administration of the bromides in combination with opium or morphine constitutes the so-called Flechsig treatment. The patient is subjected to a continued treatment with opium or its alkaloid in increasing doses, and afterward when the toxic effects are mildly produced this drug is discontinued, and a course of bromides ordered. Rectal injections of a preparation of the substance known as bromopin, has been in use in Germany in doses of ♏xv. The patient is forbidden to use any salt in his food. The nightly enemata of this substance must be increased until 3 or 4 gm. are taken.

The hypophosphites act admirably where there is weak digestion, and if the bromic state becomes too profound it will be found that some preparation of iron, strychnine, and quinine will dispel the symptoms. Great care should be taken not to push the latter too far.

Delasiauve refers to no less than eighty-nine remedies or forms of treatment, and this is but a small number when we consider that his book appeared nearly half a century ago, and that new remedies are constantly being recommended. The discovery of the bromides, as I have already stated, constitutes the only real advance. As to the other remedies it will suffice if I enumerate chloride of potassium, sulphate of zinc, oxide of zinc, sulphate of copper, chloride of gold, nitrate of silver, and phosphorus, as remedies which have had their day and which are still occasionally of service; while the list of vegetable remedies is simply legion. Valerian, camphor, the camphor monobromate, asafœtida, musk, castor, opium, belladonna, aconite, indigo, turpentine, and conium are among the most prominent of these.

In many cases of epilepsy, especially when it is suspected that the attacks are due to the absorption of toxic material from the intestines, it will be found that persistent and systematic antisepsis will do much good. The benefit obtained from the administration of salicylate of soda, naphthalin, and calomel, and from intestinal flushing is often very great.

Galvanism is the only form of electricity that ever does any good, and this only in exceptional cases. The current from no more than ten or fifteen Leclanché cells should be used, one electrode being placed anteriorly and the other posteriorly upon the head. Static electricity is useless; chloroform and ether may be resorted to when the status epilepticus is found, but unless the convulsion be very severe, I prefer to administer nitroglycerin or the amyl nitrite.

The lighter attacks are very obstinate, and are not helped to the same extent as are the more severe ones. Belladonna, ergot, and hyoscyamus have all been tried with various degrees of success. I have found nitroglycerin to be of great benefit in some cases, and it should be prescribed with the idea of producing a continued state of moderate cerebral hyperæmia.

An important indication is the provision of remedies for the abortion of attacks. When the aura is of a sensory character and begins in an extremity, the use of an encircling blister or ligature about the arm will, if the paroxysms are frequent, or if the patient has time to take preventive measures, stop the progress of an attack. One of my patients, whose aura often begins in the arm, provides himself with a rubber band which he hastily slips over his hand. Brown-Séquard recommends forcible flexion of the wrist. The inhalation of ammonia or of nitrite of amyl, or the prompt resort to a tablet containing from gr. $\frac{1}{100}$ to $\frac{1}{25}$ of nitroglycerin, will ward off the fits. A glass of sherry or some alcoholic stimulant will also often act very promptly. It is well for the patient to keep such a draught by his bedside, to take as soon as he awakens, if he has morning seizures.

The diet of the epileptic should be of a vegetable nature. Meats are highly injurious, but the *moderate* use of game, poultry, fish, and oysters is to be advised. Fresh vegetables, fruit—except grapes,—milk and cold bread, should form the chief articles of diet. Stimulants are, of course, out of the question in most cases, but coffee, which is usually denied the patient, is (if mild) by no means so hurtful a thing as it is ordinarily supposed to be.

Friction, cold baths, and exercise are to be insisted upon, and mild intellectual labor is good for the subject. Steam or furnace heat is responsible as an exciting cause in many cases, and if possible open fires, properly guarded, should be placed in the patient's room.

Surgical measures have been of avail, if we are to believe all the reports; yet the experience of many successful surgeons, who have watched their cases for a long time, is against their efficacy. If they are to be used it should only be in cases in which the evidence of a traumatic origin is very clear.

Dr. W. Briggs[12] seems to have had extraordinarily favorable results from trephining, for of 30 cases of the traumatic variety in which he performed the operation, 25 were cured, 3 relieved, 1 was not helped, and 1 died. Walsham's[13] results were not quite so favorable. Of 130 cases of traumatic epilepsy operated upon, 75 were cured, 18 improved, 7 not helped, and 30 died.

In some examples it will be found that the aura proceeds from a cicatrix upon the scalp, and the exsection of this, even if no removal of bone is undertaken, may be sufficient. In such cases as those reported by Lande,[14] in which a neuritis was the cause of the convulsion, exsection or nerve-stretching might do good, but of course such hopeful results are problematical.

Dr. Frederick Petersen has summed up his conclusions relative to the care and colonization of epileptics as follows:

"All are to be treated in accordance with the usual regulations as to diet, hydrotherapy, and medicinal agencies, with the hope that in this way beween one and six per cent. of them may be cured, and the disorder in a larger percentage ameliorated.

"Out-of-door employment in agriculture and kindred pursuits is to be provided in abundance. All manner of trades and occupations are to be carried on in an epileptic community, organized on the village plan. Facilities for education are to be afforded to almost every extent.

"Amusement and entertainment and the enjoyment of social intercourse are to be privileges from which no epileptic will hereafter be debarred.

"In this way the happiness of a large number of these miserable creatures will be materially increased, in spite of the distressing disease which they are called upon to suffer, usually for the whole of their lives; and though remedial agents applied to their malady may prove inefficient, their fate can never be as wretched or hopeless as it has been throughout the world heretofore."

Allan McLane Hamilton.

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[1] Traité de l'Epilepsie, p. 55.
[2] Archives of Medicine, iv., 1, 1880, p. 1.
[3] N. Y. Med. Jour. and Obstet. Review, June, 1882.
[4] West Riding Reports, vol. iii., p. 315; vi., p. 266; Brain, iii., 2, p. 192.
[5] Untersuchungen über die Lokalisation der Functionen der Grosshirnrinde des Menschen, p. 63.
[6] *Loc. cit.*, p. 11.
[7] Archives of Practical and Scientific Medicine and Surgery, Philadelphia and New York, 1873, i., 360.
[8] Annales Méd.-Psych., 1852.
[9] On Epilepsy, etc., 1870.
[10] The Medulla Oblongata, etc.
[11] Archives de Méd., Dec., 1869.
[12] American Practitioner, July, 1884.
[13] St. Bartholomew's Hospital Reports, vol. xix.
[14] Mém. et Bulletin, Société de Méd. et Chirurgie de 1874, i., 56–65.

EPITHELIOMA. See *Carcinoma.*

EPITHELIOMA OF THE SKIN, MULTIPLE, BENIGN, CYSTIC.

—(Synonyms: Epithelioma adenoides cysticum [Brooke]; Acanthoma adenoides cysticum [Unna].)

SYMPTOMATOLOGY.—The affection is characterized by the presence of numerous pale-yellow, pearly, or pinkish-colored nodules, from the size of a pin's head to that of a pea. The small growths are quite firmly embedded in or project above the skin. Some of the tumors are translucent and closely resemble vesicles, while others are made up of milium-like bodies and are traversed by minute capillaries. The face, scalp, neck, upper parts of the back and chest are the sites of predilection. In general the growths are discrete, but they tend to group themselves about the root and alæ of the nose, the eyebrows, and the mouth. The confluence of several nodules has been noted.

In the majority of cases heretofore reported the affection has been observed at or before the age of puberty.

The small, pinhead-sized growths increase slowly in size until they attain the size of a split pea, seldom larger, and in very exceptional cases they only undergo ulceration or disappear spontaneously.

They impair in no way the general health nor do they give rise to subjective sensations of any kind. The entire course of the disease, except in the case reported by Dr. White,[1] is so free from any evidence of malignancy that the word *benign* has been employed to qualify the term *epithelioma* used to designate this singular eruption. White's patient, in addition to numerous small nodules of the usual type, presented three or four open epitheliomatous ulcers involving the entire thickness of the skin.

Single, hemispherical, brownish-red, or translucent nodules have been removed from the ala of the nose, the eyelids, or other parts of the face and have been found to have a structure identical with or closely allied to that of the multiple benign tumors in question. They may develop in early adult life or in older individuals, but they pursue a relatively benign course.

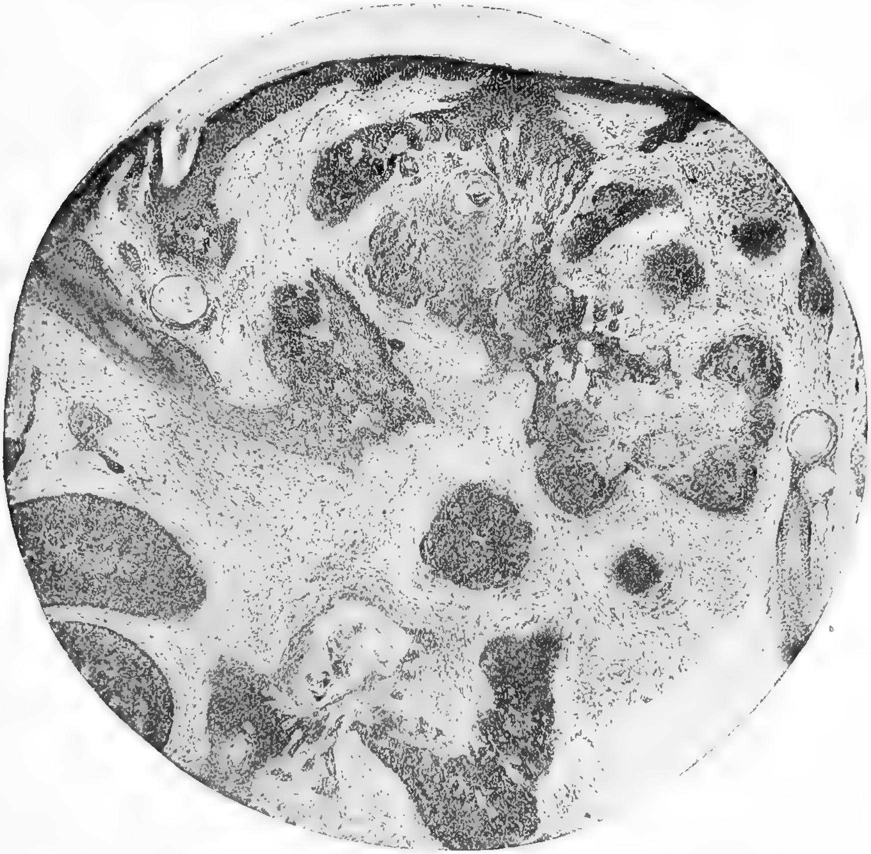

FIG. 1922.—Multiple Benign Cystic Epithelioma showing Down Growth of Surface Epithelium. Spencer, one inch; ocular, one inch and one-quarter. (Original.)

The cause of the affection is obscure. In Brooke's[2] and my own cases[3] a distinct hereditary history was obtained. The onset of the affection at the age of puberty may depend in some manner on the general stimulus to which all epithelial tissues are subjected at this time. The view has been held by some that these tumors depend on misplaced embryonic epithelial cells which remain latent until puberty or later in life.

Pathology and Morbid Anatomy.—In the earlier descriptions of the affection the cases described by Jacquet and Darier[4] as "Hydradénomes eruptifs," by Török[5] as syringo-cystadenoma, and by other writers with designations of similar meaning, were considered to be of the same general nature.

Unna[6] has, however, wisely separated the class of cases described by Jacquet and Darier, Török and others from those of Balzer, Brooke and myself; the first group of cases being, in his opinion, adenomata of the coil ducts, to which he gives the name "syringadenomata," while the second group undoubtedly originate in the epidermis and are called by him "acanthoma adenoides cysticum."

The microscope shows these benign epithelial growths to be made up of proliferating masses and narrow tracts of small epithelial cells corresponding to those in the lowermost layer of the epidermis and external root sheath of the hair follicles. The origin of the new growth from the epidermis and hair follicles is shown in Fig. 1922, which represents a section from the original case described by me.[7] Similar observations have been made by Brooke[8] and by Bowen (in White's case).

The epithelial masses and tracts on their outer side are usually surrounded or defined by a well-marked layer of cylindrical cells, a condition which characterizes many benign epithelial growths. Atypical "pearl bodies," enclosing horny or colloid tissue as well as colloid degeneration of individual epithelial cells, have also been met with. The connective tissue between the new cell growths is somewhat condensed and the seat of a moderate infiltration of lymphoid cells.

Treatment. — Some of the small tumors can be removed by incising the overlying epidermis and expressing them by moderate pressure. If this method is not successful the dermal curette may be employed. The resulting wound readily heals with a small depressed scar.

The use of caustics is not advocated, as it is possible by their improper use to evoke a latent malignancy.

John A. Fordyce.

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[1] Jour. Cutaneous and Gen.-Urin. Dis., p. 477, 1894.
[2] British Journal of Dermatology, p. 271, 1892.
[3] Journ. Cutaneous and Gen.-Urin. Dis., p. 459, 1892.
[4] Ann. de Dermat. et de Syph., p. 317, 1887.
[5] Monatsheft f. prakt. Dermat., p. 116, Bd. viii.
[6] Histopathology of Diseases of the Skin, p. 117.
[7] Jour. Cutaneous and Gen.-Urin. Dis., p. 459, 1892.
[8] Brit. Jour. of Dermat., p. 269, 1892.

EPITHELIUM.—Epithelial tissue is composed of cells placed close to each other, the intercellular substance being reduced to a minimum.

The cells, as a rule, are soft, yielding readily to press-

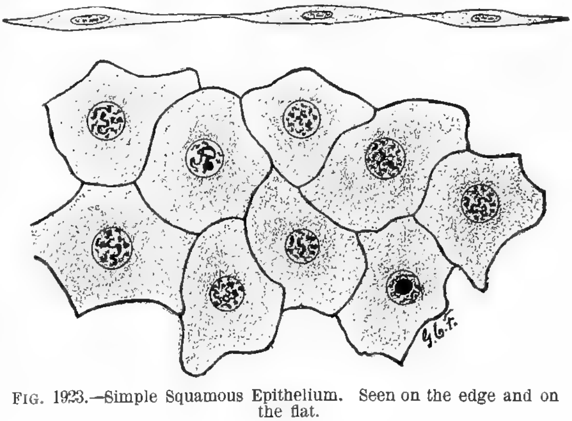

FIG. 1923.—Simple Squamous Epithelium. Seen on the edge and on the flat.

ure, and consequently they show a great diversity in their shapes. The cytoplasm may be either clear, or finely or coarsely granular. Each cell has a nucleus, which is embedded in the cytoplasm. There are a few instances in which the cells are without nuclei.

All epithelium rests on a structureless membrane, the *basal membrane* or *membrana propria.* This membrane is believed to be of connective-tissue origin, though by some it is considered a product of the epithelial cells.

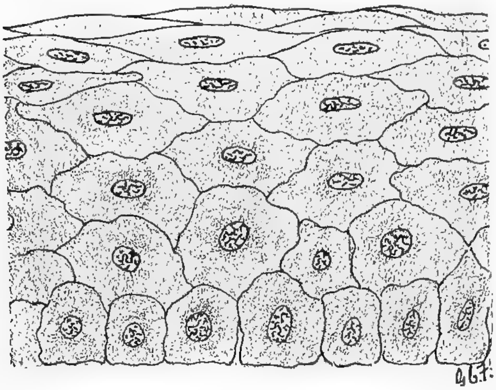

FIG. 1924.—Stratified Squamous Epithelium. Section of epithelium lining the œsophagus.

The free surface of some epithelial cells, especially those of the cylindrical type, shows a sharp differentiation from the remainder of the cytoplasm. This appears as a thickened free border and is known as the *cuticula.* The cuticulæ of adjoining cells form, through fusion, the *cuticular membrane* (Fig. 1927, *A*). In some cells the cuticula shows a longitudinal striation, which is caused by prolongations of fine processes of the cytoplasm into it. This striation is especially well marked in the epithelial cells on the surface of the mucous membrane of the small intestine.

As a rule blood-vessels are not present in epithelial tissue. Recently they have been found in the epithelium of some of the lower animals, and they are known to be present in one place in the body of the higher animals—the stria vascularis of the cochlea. The nerve supply is rich.

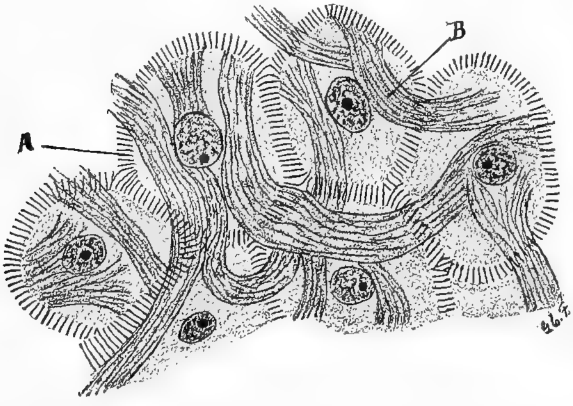

FIG. 1925.—Spine or Prickle Cells. *A*, Spines projecting from the edges of the cells; *B*, filaments of the cytoplasm passing from cell to cell.

CLASSIFICATION.—The epithelia are classified as follows:

1. Simple—consisting of one layer of cells.
(*a*) Squamous.
(*b*) Cylindrical or columnar.
2. Stratified—consisting of several layers of cells.
(*a*) Squamous.
(*b*) Transitional.
(*c*) Cylindrical or columnar.
3. Modified.
(*a*) Ciliated.
(*b*) Mucous.
(*c*) Pigmented.
4. Specialized.
(*a*) Glandular epithelium.
(*b*) Neuro-epithelium.

Simple Squamous Epithelium.—The cells of this form of epithelium are thin, scale-like, irregular in shape, and are laid down in a single layer. A surface view (Fig. 1923) shows them arranged in the form of an irregular mosaic; when seen on the edge they show a bulging of the cytoplasm at the situation of the nucleus, with a thinning out of the same at the edges of the cell (Fig. 1923).

This type of epithelium occurs as a lining to the capsule of Bowman in the glomerulus and in the descending arm of Henle's loop in the kidney; also as non-nucleated cells—respiratory epithelium—in the terminal bronchi, infundibula, and air vesicles of the lung.

Simple Cylindrical Epithelium.—The cells of this form of epithelium are long and narrow, with the base of the cell rounded off (Fig. 1927, *A*). The nucleus, oval in shape, is embedded in the cytoplasm near the base of the cell. The cuticula is well developed in the cells of the small intestine. The height of the cells varies in different situations, sometimes being high, sometimes low. In some instances the diameters of the cell are about equal. Such cells when seen in section have the appearance of small squares, with the nucleus embedded in the central portion of the cytoplasm. This form of epithelium is known as cuboidal.

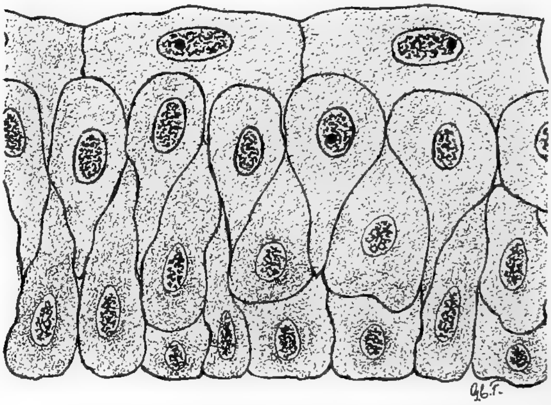

FIG. 1926.—Transitional Epithelium. Section of the epithelium lining the bladder.

Simple cylindrical epithelium occurs on the surface of the mucous membrane of the stomach, of the small and large intestines, and of the membranous and penile portions of the male urethra, in tubular glands, in portions of the uriniferous tubules, and in the ducts of compound glands. Cuboidal epithelium is seen in the small bronchi, in portions of the uriniferous tubules, and in the smaller ducts of compound glands.

Stratified Squamous Epithelium (Fig. 1924).—In this type of epithelium the cells are laid down in two or more layers, the cells of the various layers differing greatly in shape. The cells of the deep layer are cuboidal or low cylindrical; those of the middle layers polyhedral; those of the surface, alone, flat or scale-like.

The large cells of the middle layers give off short, fine processes, which join similar processes of adjoining cells (Fig. 1925, *A*), the *spine* or *prickle cells.* These spinous processes are also known as the *intercellular bridges*, and they enclose spaces in the intercellular substance, the *intercellular spaces.* It is through these spaces that the fluids for the nourishment of the cells circulates. By some these intercellular bridges are believed to be filaments of the cytoplasm which pass from cell to cell (Fig. 1925, *B*).

Stratified squamous epithelium rests on a connective tissue which is thrown up into conical-shaped projections—the papillæ—which are covered by the basal membrane. These papillæ project into the epithelium in such a manner as to form a series of hills and valleys. The papillæ contain a rich capillary network of blood-vessels from which the nourishment of the overlying epithelium is derived.

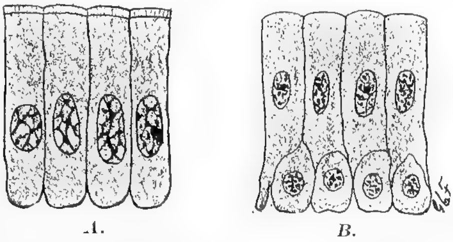

FIG. 1927.—*A*, Simple Cylindrical Epithelium; *B*, stratified cylindrical epithelium.

The cells of the deeper layers, receiving the greatest amount of nourishment, increase rapidly by mitosis, and pushing outward they replace the cells of the outer layers, the surface cells being thrown off.

In the epidermis of the skin, where the surface cells are horny, there are developed, beneath these, cells which pass through the intermediary stages of cornification. This type of epithelium is found on the surface of the skin, and on the surface of mucous membranes which become continuous with the skin, as that of the buccal cavity, vagina, etc.

Transitional Epithelium (Fig. 1926).—Transitional epithelium is stratified, consisting of from four to six layers of cells, and lies on connective tissue which is unprovided with papillæ. The surface cells are large and flat, with a convex free border, their under surface being pitted. This pitting is caused by the underlying cells pushing their heads into the soft cytoplasm of the surface cells. The cells of the deeper layers are irregularly cuboidal; those of the middle layers pyriform or polyhedral in shape.

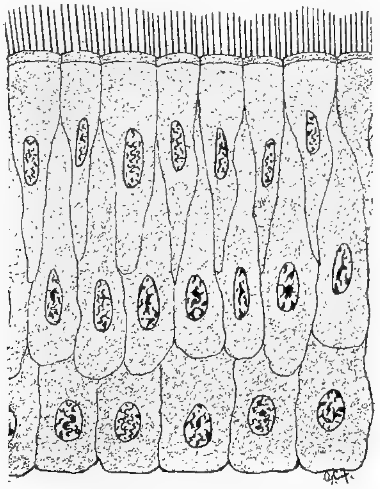

FIG. 1928.—Stratified Cylindrical Ciliated Epithelium. Section of the epithelium lining the trachea.

This type of epithelium is found on the surface of the mucous membrane of the urinary bladder and of the pelvis of the kidney.

Stratified Cylindrical Epithelium (Fig. 1927, *B*).—In this type of epithelium the surface cells alone are cylindrical in shape, their basal ends being pointed or branched.

The cells of the deeper layers are irregular in shape, and those of the basal layer cuboidal or low cylindrical. In most instances the cuticula is well developed.

This form of epithelium is found lining the largest ducts of glands; it covers the palpebral conjunctiva, portions of the mucous membrane of the male urethra, and the mucous membrane of the vas deferens.

Ciliated Epithelium.—Ciliated epithelium occurs in both the stratified and the simple forms, the ciliated cells, in man, being of the cylindrical type. In the stratified form the arrangement of the cells is similar to that of stratified cylindrical epithelium; in the simple form it consists of a single layer of ciliated, cylindrical cells.

The free surface of ciliated cells has a well-marked cuticula, from which seem to spring hair-like structures—the cilia (Fig. 1928). The length of the cilia varies with the situation of the cell. In the trachea and bronchi they are short, while in the epididymis they are long, about ten times the length of those in the trachea. The number of cilia to a cell also varies, being from twelve to twenty-five. They are now regarded as filamentous prolongations of the cytoplasm which pass through and project beyond the cuticula.

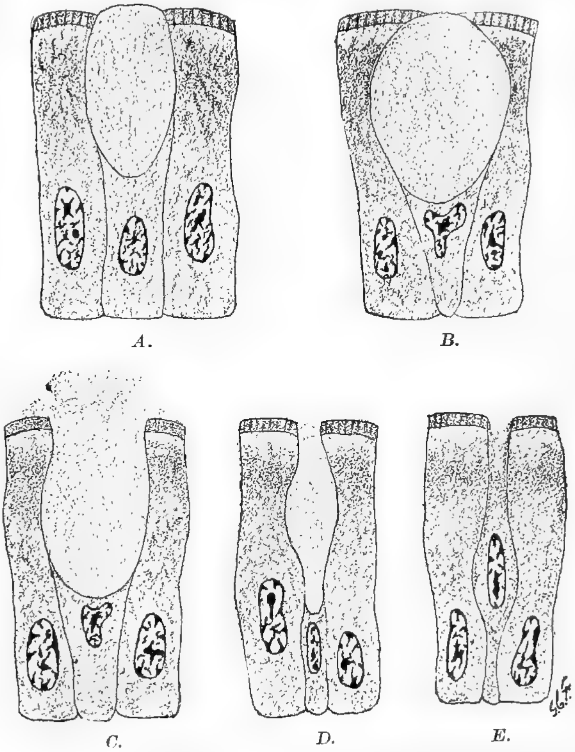

FIG. 1929.—Mucous or Goblet Cells. *A*, Early stage of the formation of the mucin; *B*, cytoplasm nearly all converted into mucin; *C*, cell discharging its contents; *D*, collapse of the mucous cell; *E*, regeneration of the cell.

The movement of the cilia is automatic, not being under the control of the nervous system. The movement of a single cilium resembles that of a whip-lash, the number of vibrations being estimated at ten per second. The beats of the cilia do not take place at the same time in all cells, one cell after another taking up the movement, which passes through a series of cells in successive waves. The rapidity of the vibrations is increased by warmth, up to a certain point. Cold, chloroform, and an increase of temperature up to 50° C. may cause the movement to cease.

Mucous Epithelium.—The mucous epithelial cell is regarded by some as an unicellular gland. It is found distributed throughout the epithelium of the intestinal tract, trachea, and bronchi. Owing to its shape it is commonly called a goblet cell.

Mucous cells are formed from cylindrical epithelial cells, the most of the cytoplasm of which is gradually converted into mucin. The process begins at the free surface of the cell (Fig. 1929, *A*), and progresses until the cytoplasm, excepting a small portion containing the nucleus, is changed. The latter becomes crowded to the base of the cell. The cell increases in volume (Fig. 1929, *B*), finally it ruptures at its free surface and its contents are discharged (Fig. 1929, *C*). The cell then collapses (Fig. 1929, *D*), and from its basal part which contains the unchanged cytoplasm and nucleus, a new cell is formed (Fig. 1929, *E*).

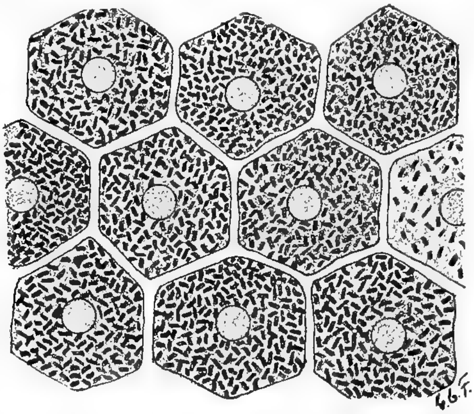

FIG. 1930.—Pigmented Epithelial Cells from the Retina.

Pigmented Epithelium.—In some parts of the body there occurs an epithelium, the cytoplasm of which is more or less filled with granules of pigment. These granules may be spherical or rod-like in shape and of a color varying from light brown to black.

This type of epithelium forms one of the layers of the retina (Fig. 1930) and is also found in the deep layer of the epidermis of the colored races.

Glandular Epithelium.—This form of epithelium lines the alveoli or secreting portion of glands. The shape of the cells varies in different glands, in some being cylindrical, in others polyhedral or irregular. In some glands two types of cells occur. Many of the mucous glands have an internal layer of cylindrical cells with a moderately clear cytoplasm, and between these and the membrana propria a second type, viz., granular cells (Fig. 1931). These granular cells form the crescents of Gianuzzi or demilunes of Heidenhain. The cardiac glands of the stomach also contain two types of cells, the internal or chief cells and the large granular peripheral cells—the acid cells.

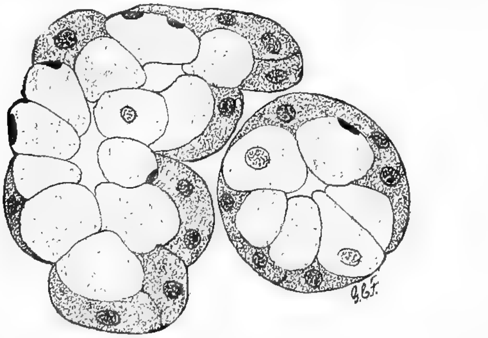

FIG. 1931.—Glandular Epithelium. Mucous acini from human submaxillary gland. The light central cells are the mucous cells; the dark cells form the crescents of Gianuzzi.

The microscopic appearance of gland cells varies with their state of activity. The resting cell is generally granular and dark in appearance, the granules staining intensely, and the volume of the cell is reduced. As the cell passes into the active state its granules cease to stain; small vacuoles appear in the cytoplasm, which becomes clearer; and the volume of the cell increases. After the cell has discharged its secretion the cytoplasm may become nearly clear and the cell returns to the resting state. In some glands (for example, the mammary gland) a portion of the external part of the cytoplasm is used up in the process of the formation of the secretion, the basal part with the nucleus remaining unaltered. From this portion the cell is reconstructed. In other glands the entire cytoplasm is used up and a new cell takes its place.

Many gland cells discharge their secretion not only from their free surfaces, but also from all sides. In such cases the cells are surrounded by a network of canaliculi, which take up the secretion and convey it to the lumen of the gland by a "duct."

Neuro-epithelium.—Neuro-epithelium is a highly differentiated type and occurs in the sense organs. The rods and cones (Fig. 1932, *A*) of the retina; the hair cells of the organ of Corti of the cochlea (Fig. 1932, *C*); and the hair cells of the macula and crista acusticæ (Fig. 1932, *B*) are examples.

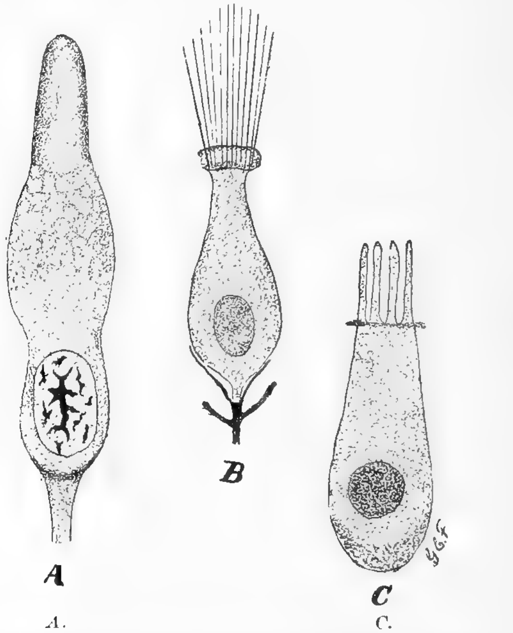

FIG. 1932.—Neuro-epithelium. *A*, Cone from the retina; *B*, hair cell from the crista acustica; *C*, hair cell from the organ of Corti of the cochlea.

Neuro-epithelial cells consist of two portions: the basal, containing the nucleus, and which is in close contact with the nerve terminations; and the outer or perceptive portion, which usually terminates in the form of thick, hair-like processes.

Mesothelium and Endothelium.—These two types of cells, on account of their characteristics, are now classified by many as simple epithelium. If we trace them back to their origin in the blastoderm it is found that they are both derived from the mesoderm or middle layer, but from different cells. Mesothelium, which lines the cavities of the peritoneum, pleura, and pericardium, is derived from the cells which line the original body cavity—the cœlom. At the suggestion of Minot the term mesothelium has been applied to them.

Cells of a similar type form the capillaries, and line the interior of blood and lymph vessels, synovial spaces, bursæ, tendon sheaths, and the anterior chamber of the eye. These are differentiated mesochymal cells (Minot) and the term endothelium is alone applied to them.

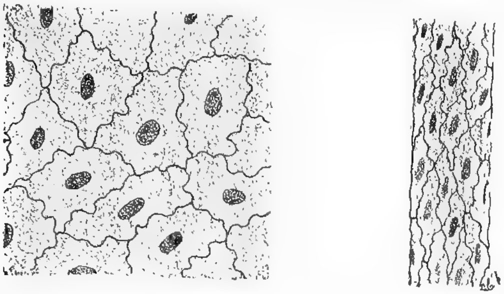

FIG. 1933.—*A*, Mesothelium Covering the Surface of a Serous Membrane; *B*, endothelium lining a blood-vessel.

Mesothelial cells (Fig. 1933, *A*) are thin, flat cells, the cytoplasm of which is slightly granular. Their nuclei may be either oval or spherical in shape and they project above the surface of the cytoplasm. The general shape of the cells is polyhedral with more or less wavy edges, and they are united by an exceedingly slight amount of intercellular substance.

Endothelial cells (Fig. 1933, *B*) are, as regards structure, like the mesothelial. Their shape is an irregular oblong one with markedly serrated edges.

These two types of cells are always laid down in a single layer. *George C. Freeborn.*

EPULIS. See *Sarcoma.*

EQUILIBRIUM AND EQUILIBRATION.—The term equilibrium is used to indicate a state in which all the muscles of the body are under such nervous control that when called upon they can execute some co-ordinate movement or resist the force of gravity. Equilibrium is of great importance in animal life, as can be readily understood, and it is by no means a simple phenomenon. That the motor apparatus may act properly it is necessary that it should receive sensory impressions informing it of the position of the body at any movement, and every known sense appears to contribute the necessary information. A combination of these sensations constitutes the sense of equilibrium.

Before discussing equilibrium and equilibration with regard to its nervous control or how it is maintained in the human body, it is necessary that we should have a clear idea of the position of the centre of gravity of the body and how the position of this centre may vary in different postures. It is mainly owing to the researches of the Weber brothers, Barellus, Harless, and Meyer, and more recently Braune and Fischer, that the position of the centre of gravity of the body has been determined.

In the *erect posture*, roughly speaking, the centre is situated between the pubes and buttocks, and is farther from the sole of the foot than from the crown of the head. A variation may be pointed out here, viz., that the position of this centre will vary according to a man's build. A man heavily built in his shoulders and arms will naturally have his centre of gravity higher than a man with narrow shoulders, light arms, but powerful legs and buttocks. Meyer's method for determining the centre of gravity in the antero-posterior plane was as follows:

A soldier standing at "attention" leaned forward so as to throw the weight of the body upon the front of his feet. A line plumb to this point would pass through his centre of gravity. The man then extended his limbs at the ankle-joint until he nearly lost his balance backward. A vertical line from his heels again passed through his centre of gravity which lay naturally where these two lines crossed one another. This was found to be in the region of the body of the second sacral vertebra.

Braune and Fischer's method was more complex and their experiments were performed upon the cadaver. For a full account of this I would refer the reader to their original articles. According to their method the centre of gravity for the whole body was about 4.5 cm. above a horizontal line joining the centres of the heads of the two femora, or on a level with the third sacral vertebra (upper border).

These observers have claimed that the centre of gravity of the body is found to fall in the same frontal plane as that in which all the axes of rotation of the joints lie. It can be readily understood from this that anatomical variations will very considerably alter this statement, this being particularly true of women in pregnancy or of abnormally stout men. In such persons, when in the erect position, the centre of gravity must lie well away from the plane containing these joints, the abdominal weight necessitating an arching of the spine, the shoulders being thrown back, bringing the centre posterior to the normal plane.

It has been pointed out by the Weber brothers, that the fact that the various centres of gravity of the body form a vertical line when the body is in an erect position, is sufficient to maintain the body in an erect position without any muscular effort. (According to Braune and Fischer the centre of gravity for the head was plumb above the atlanto-occipital joint.) According to them the centre of gravity plumbs behind the hip, in front of the knee and through the ankle-joint. Meyer claims that the centre plumbs in front of the ankle-joint. If this is so the calf muscles would have to act toward the support of the body. In bending forward or backward the centre of gravity will fall either forward or backward, as the case may be (see Fig. 1934).

In the most comfortable standing position the centre plumbs really in front of the ankle. When it falls farther forward than this, as for instance when it falls over the ball of the great toe as in the military position of "attention," there is a sensation of straining and this posture cannot be long supported. In fact there is no erect position of the body which can be maintained for many minutes without exhaustion, although it has been claimed that muscular action is not necessary to maintain the body in the erect position. It may be noted that we instinctively and frequently change our position and so ease the various sets of muscles when standing for any length of time.

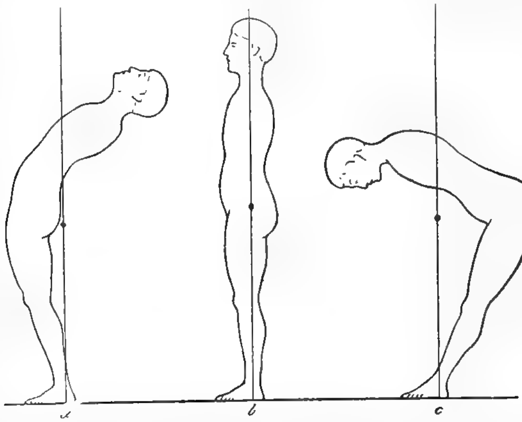

FIG. 1934.—The Position of the Centre of Gravity is Indicated by a Dot in Each of the Postures *a*, *b*, and *c*. In *a* and *c* it lies outside the body altogether.

Walking and Running.—In these modes of progression there are certain forces which have to be so balanced that the speed of progression is neither diminished nor increased, and also that during locomotion the body shall remain erect. Three forces may be considered: first, the weight of the body to be supported; second, atmospheric resistance, which naturally varies with the speed of progression and the size of the surface presented to the air; and thirdly, the friction of the ground on which locomotion is performed. Against these forces we have the muscular force of the body, which, by altering its position, raises the centre of gravity by shortening the legs and so gives it naturally a forward impetus.

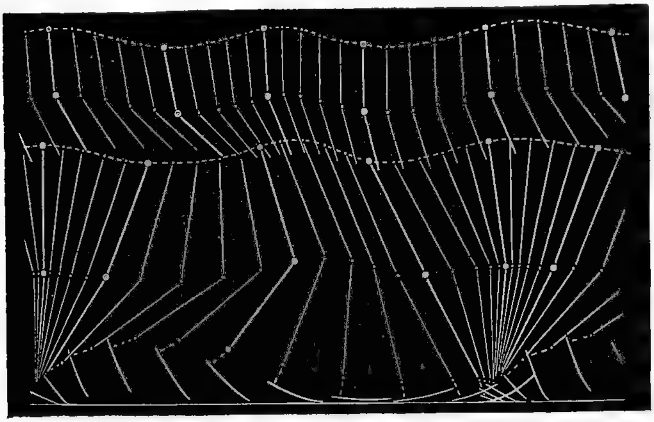

FIG. 1935.—Diagram showing a Man's Movements when Walking. Read from left to right. (From a chronophotograph, after Marey.)

During locomotion the centre of gravity constantly and rhythmically changes its position as the body changes its shape. The centre of gravity is moved not only on a horizontal plane forward through the median sagittal plane of the body, but also from side to side. This side-to-side movement is naturally due to the fact that a different leg is supporting the weight of the body every moment.

Figs. 1935 and 1936 give Marey's chronophotographs of a man's movements when walking and running. In these it can be seen that the plumb from the centre of gravity falls through different portions of the leg and ankle at different stages of progression. Should the body progress forward in a perfectly erect position and no muscular exercise be required to keep the body erect, the resistance of the air would be quite sufficient to cause the body to tumble backward, but to correct this the body is bent forward so that the centre of gravity shall be thrown in front of the hip-joint.

The nature of the ground over which progression is taking place hardly needs to be considered here, as it can readily be understood.

We now have to consider the various sensory impressions which are concerned in maintaining the body in the state of equilibrium. These may be classified as visual, tactile, muscular, and labyrinthine.

The importance of the eye in equilibrium can be very easily demonstrated. If one tries to walk while looking through a prism, the position of objects is so distorted that improper co-ordination of the various muscles results; where under normal conditions, knowing the position of objects to be determined by the sense of sight, we would have perfect co-ordination. Again, when we look at rapidly moving objects, wrong ideas of equilibrium are commonly formed through the visual sense, and there may be a strong tendency for the body to move itself in one direction or another. These phenomena may primarily be due to, we might say, deceiving educated senses, for the reason that people born blind are not troubled with inco-ordination of the muscles and neither are people from whom the eyes have been removed.

The tactile sense also plays an important part in the sense of equilibrium. The contact of the soles of the feet with the ground or of various parts of our body with surrounding objects conveys to us considerable knowledge with regard to the position of the body. We see a remarkable example of the value of this sense in the disease known as "locomotor ataxia" in which the muscular power of the lower limbs is not impaired, but sensory impressions are profoundly altered. The inco-ordination in this disease results from the false tactile impressions and not from any disease of the muscles, which retain their original strength. We can see this same phenomenon in persons who have had the soles of their feet frozen. Here their tactile impressions are not received by the sensory end organs, consequently do not reach the higher centres, and so inco-ordination will result. Attention has been called to a peculiar tactile phenomenon in the fact that air waves exert an influence upon the tympanic membrane (?), and so we are capable of appreciating the presence and to some extent the character of near objects (irrespective of sound). Whether this involves the nerves of common sensibility or those distributed to the internal ear is disputed.

The muscular sense, whether our bodies are moving or not, is another active factor in determining the condition with regard to the tension and position of our muscles. That the various skeletal muscles are acting reflexly more or less all the time is shown by the fact that from a person with the eyes closed, standing in an erect position and having a writing point attached to the head, a graphic record may be obtained showing a peculiar swaying motion of the body. Evidently different groups of muscles are successively contracting. A peculiar sensation which has been experienced by almost every one is that of going up-stairs in the dark, miscalculating the number of stairs, and taking an extra step at the top of the stairs. The sense of loss of equilibrium is at once experienced. A patient with failure of tactile or muscular sense, as in the above-mentioned disease, locomotor ataxia, is unable to stand with the eyes closed. Here we see the importance of the combined loss of the visual, tactile, and muscular sense.

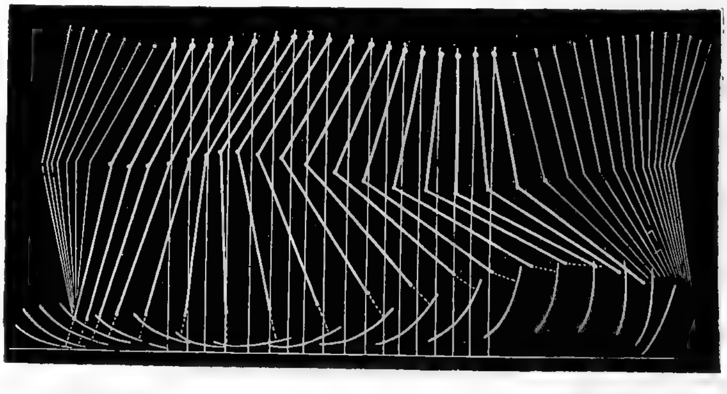

FIG. 1936.—Diagram of the Movements of a Man's Leg in Running. Read from right to left. (From a chronophotograph, after Marey.)

A normal combination of all these senses gives us our idea of position. Should the impressions arising from any of them clash with our conscious perception formed through the other senses, a disturbance of equilibrium results and the usual result of this disturbance is the sensation of nausea or dizziness. An example of this clash-ing with the resulting dizziness is seen in people on the top of a high building. The tactile organs of the soles of the feet and the muscular sense organs of the limbs are originating perceptions which indicate that one is standing on the solid earth. Yet the eyes at the same time originate perceptions that indicate that the solid earth is far below.

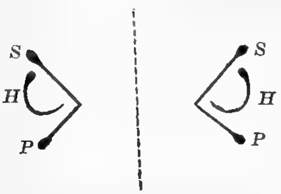

FIG. 1937. – Diagrammatic Horizontal Section through the Head to Illustrate the Planes Occupied by the Semicircular Canals. *S*, Superior; *H*, horizontal; *P*, posterior. (After Waller.)

We see from the above that the sense of equilibrium is served by various special senses. However, we have good reason for believing that there is one special sense organ which determines the position and direction of the movements of the head, and consequently of the whole body. This organ consists of the system of semicircular canals in the internal ear (anterior, posterior, and external).

Various experiments performed on birds show that a motor disturbance invariably follows division of any of these canals. The animal shortly after operation, whenever it is disturbed, undergoes peculiar forced movements with rolling of the eyes. When at rest the animal does not maintain its perfect erect position, its legs spreading farther apart than normal and its body coming closer to the ground. The effect of this operation varies, of course, very considerably, it depending altogether on the number of the canals cut. Some observers have claimed that it is the activity of the hair cells on the *cristæ acusticæ* of the ampullæ of the semicircular canals, which are irritated by the increased or diminished pressure of the endolymph in them, which gives rise to a nervous impulse and so originates various ideas of position.

The anatomical position and relationships of these canals in the human being have been very extensively studied by Crum Brown, who pointed out that the three canals of each side lay in the three dimensions of space and that the canals of each side are almost at right angles to one another (see Fig. 1938). Any movement of the head will constantly produce an increase of pressure in the ampulla of a canal of one side, with a corresponding decrease of pressure in the same canal on the opposite side, and this by exciting the hair cells in them originates the sense of movement. This assumption can be considerably strengthened by experiments on man. A person with the eyes bandaged, tactile and muscular sense eliminated, supported on a rotating table, can determine very correctly in what direction and through how great an angle he may be rotated. It will be found in the same experiment that after being rotated for a few moments and then the table brought to a standstill, the person will experience the sensation of rotation in the opposite direction. Patients with some disease of the internal ear are very seldom subject to dizziness caused by rapid rotation or the motion of a swing. James has pointed this out in deaf-mutes who are subject to this and to another well-known peculiarity. Should a deaf-mute dive into deep water when bathing, the pressure of the water surrounding the body is nearly equal and so eliminates localized pressure; the mute may then, instead of swimming to the surface of the water, continue his progress toward the bottom—in short, he cannot distinguish whether he is going up or down. In support of this fact it may be mentioned that in birds and fishes whose environment is such that muscular and tactile sense can contribute little to the sense of equilibrium, the semicircular canals are very greatly developed. We find also that in cases of disease of the semicircular canals in which the pressure in them is considerably altered we have well-marked symptoms of vertigo and inco-ordination. Disease of the cochlea does not produce this. According to Lee, section of these canals in fish produces no forced movement, but section of the nerves supplying the ampullæ invariably gives rise to forced movements. This observer also found that when a fish is placed in different positions, there is an opposite movement of the dorsal fin and of the optic axes determined by the semicircular canal in whose plane the movement is made. Lee places great importance upon the presence of otoliths in the vestibular sacs of the nerve terminals and the *cristæ acusticæ*. These bodies form large masses in the ears of fishes and they undoubtedly exert considerable pressure on the hair cells.

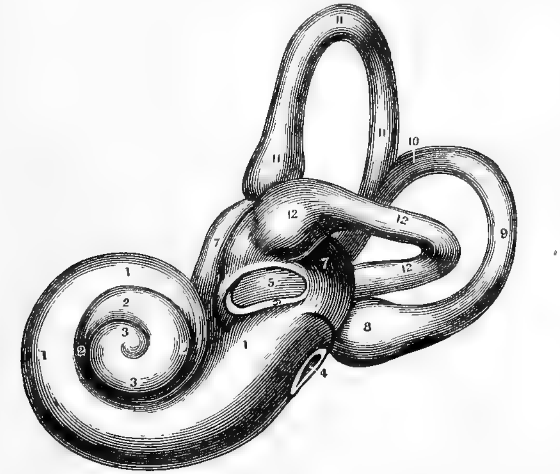

FIG. 1938.—Left Bony Labyrinth, Viewed from Outer Side. The figure represents the appearance produced by removing the petrous bone down to the denser layer immediately surrounding the labyrinth. 1, 2, 3, The first and second turns of the cochlea, and the cupola; 4, fenestra rotunda; 5, foot-plate of the stapes; 7, the vestibule; 8, 11, 12, the ampullæ of the semicircular canals; 9, 11, 12, semicircular canals.

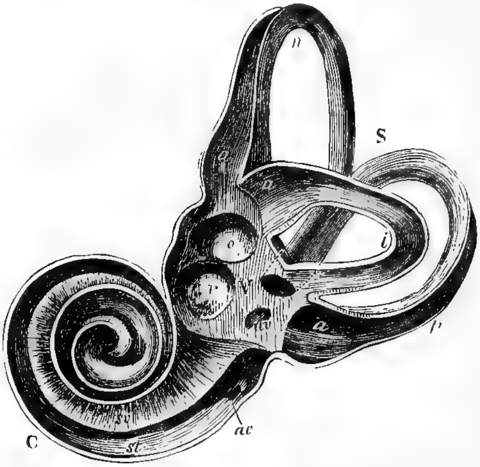

FIG. 1939.—Interior View of Left Bony Labyrinth After Removal of the Superior and External Walls. *n*, *p*, *i*, The superior, posterior, and horizontal semicircular canals; *a*, *a*, *a*, ampullæ; *av*, opening of the aqueduct of the vestibule; *V*, vestibule; *ac*, opening of the aqueduct of the cochlea; *sv*, scala vestibuli; *st*, scala tympani; *o*, fenestra ovalis; *r*, fenestra rotunda.

The semicircular canals are not entirely necessary for the preservation of equilibrium, yet the muscular, tactile, visual, and other senses supplying their quota of information regarding the position of the body may, no doubt, to a considerable extent, take the place of the semicircular canals when these are destroyed by either operation or disease.

The first suggestion of the importance of the semicircular canals in maintaining the body equilibrium may be traced to the two important researches by Purkinje in

1820, and another by Flourens in 1828. Against the usually accepted theory that the semicircular canals are the organs for determining the spatial relations of the head, Cyon contends that the semicircular canals only assist indirectly in this function. He maintains that really our knowledge of the position of the bodies in space depends more upon the nerve impulses coming from the contracted ocular muscles, pointing out that the oculomotor centres are in close relationship with the centres receiving the stimuli from the semicircular canals. Consequently on excitation of the semicircular canals oscillatory spasms of the ocular muscles occur at the rate of from twenty to one hundred and fifty per minute. And this view of Cyon's that the semicircular canals influence the movement of the eyes has been partially supported by Lee (see above). Ewald has divided the labyrinth functionally into two parts, one concerned with hearing and the other with muscle tone. The former is the cochlea, and the latter the semicircular canals of the vestibule. He states that if the labyrinth of an animal be injured and then the animal killed, rigor mortis does not in most cases occur. Sewall carried out a series of experiments on young sharks and skates and claimed that cutting through the canal on one side produced no alteration in equilibrium. But should the utricle be injured and the otoliths be removed the fishes usually dived and swam toward the injured side. Ewald claims that the saccule is more concerned in the equilibrium than any other portion of the internal ear.

Anatomical evidence clearly points to the fact that the function of the semicircular canals and that of the cochlea are different. It is true that the eighth nerve supplies them both; but it is also true that the eighth nerve really consists of two divisions, a vestibular and a cochlear portion, which, although running together in the human subject (in the horse they are separate and distinct nerves), on entering the internal auditory meatus they separate and are distributed as named.

The question may now be asked, In what part of the brain are these impressions from the semicircular canals and other senses received and elaborated into the sense of equilibrium? We have seen above that nearly all the special senses are concerned in maintaining equilibrium and that the semicircular canals are of primary importance.

The cerebellum has long been regarded as the nervous centre for equilibrium and co-ordination of muscles. Certainly pathological evidence points to the fact that the cerebellum is concerned in this function, giddiness being a well-marked symptom of cerebellar disease, although it is not so well marked as in labyrinthine or eighth-nerve lesions.

Should a large portion of the cerebellum be destroyed, we have well-marked inco-ordination phenomena, and here, although sensation may remain good, the inco-ordination must be ascribed to a loss of impulses which regulate body movements without being on their way or in the cerebellum elaborated to conscious sensations.

Experimental work on the cerebellum seems to point to the fact that the organ "functions" as a whole, not in "areas" as the cerebrum, because it is so largely concerned in the innervation of the muscular system of the whole body, and this fact led Flourens and Bouillard, early observers, to express the opinion that the cerebellum was the organ of "equilibrium." The cerebellum, according to Lussana and Carpenter, receives impressions originating in the sense organs of muscles, joints, ligaments, and tendons, and it also is intimately connected with the vestibular nerve, consequently destruction of one side of the cerebellum greatly lowers the muscular tone of that side. Removal of one-half of the cerebellum gives well-marked symptoms of inco-ordination and partial loss of equilibrium. Complete removal of the organ does not give such marked symptoms, but profound lassitude is marked, following execution of movements which should be ordinarily quite unfatiguing. In unilateral ablation the animal usually lies on the side from which the portion of the cerebellum is being removed and with the trunk often curved concavely to the same side. The four limbs are usually extended, the one on the operated side more than the other. There is conjugate deviation of the eyeballs to the opposite side. As a rule, the animal cannot stand and has a great tendency to fall to the injured side. Should it try to move, it will move around in the long axis of its body toward the injured side. In a few days, the majority of these symptoms disappear. However, entire disappearance of the symptoms has not been obtained.

Although an enormous mass of work has been done on the cerebellum, very little definite knowledge has been obtained. It appears that this organ is concerned in a particular class of phenomena, rather than in a particular sense. It is more intimately concerned in receiving impulses from the various senses, more especially of those concerned with equilibrium and muscular sense. Through it habitual posture is supported and it is immediately associated with the movements depending principally on the lower cerebral sense, that is, walking and running, and not with those elaborated with the highest technical movement.

From the foregoing description we can see that the sense of equilibrium is one of the most complex phenomena in the body. As already mentioned, it is made up from impressions derived from nearly all the special senses. Experimental evidence clearly points to the fact that the semicircular canals are of primary importance, that they transmit their impulses to the cerebellum through the vestibular nerve, and the cerebellum in turn, acting through the vermis, may react upon the cerebello-spinal and vestibulo-spinal efferent system and so through these contribute a factor to the normal tonus of the spinal, cranial, and motor cells.

In conclusion it may be mentioned that although we have seen that the semicircular canals and vestibule are primarily concerned in equilibrium, yet pathological cases have been found in which a slowly progressive affection of the internal ear ultimately left these structures transformed into a bony mass in which no trace of the original soft structures remained. And in these cases there was no perceptible disturbance of equilibrium, nystagmus, or giddiness. We must therefore admit that these organs are not indispensable for equilibrium, but that some other organ or combination of organs can vicariously carry on their function.

The question may also be asked, Are the semicircular canals concerned in hearing? Certainly injury to these canals in animals does not appear to cause deafness, but it must be remembered that it is extremely difficult to substantiate any of the special senses in animals. In the human subject it is doubtful if any of these structures are ever affected without causing deafness; but it must here be noted that these structures are seldom affected in the human being without the cochlea becoming involved in the disease, so that deafness may be caused by disease of the semicircular canals, which disease would, in all probability, also involve the cochlea.

Allen M. Cleghorn.

EQUINOX SPRING.—Bennington County, Vermont.

Post-Office.—Manchester. Equinox and other hotels in Manchester.

Access.—Viâ Bennington and Rutland Railroad, a link in the Central Vermont line between Montreal and New York and 50 miles northeast of Saratoga. Manchester-in-the-Mountains, a charming village in the southwestern part of Vermont, is situated on a plateau about 200 feet above the Battenkill River, and 1,000 feet above tide-water, in a valley between the Green and Taconic ranges. For nearly half a century it has been one of the principal resorts of New England, famed alike for its beautiful scenery, fine drives, healthful, invigorating air, pure water, and numerous brooks, alive with trout. The place has been properly termed a model village, the main street being bordered by wide lawns, overarched by century-old elms and maples. Shaded by these trees are marble side-walks, and back of them the cottages in their setting of emerald, the entire absence of fences on the street giving the effect of a park. The village contains a beautiful new library building, charming drives in all directions, a strictly first-class hotel (the Equinox) and other desirable features too numerous to mention here. In the immediate vicinity is an unending variety of natural attractions. Away off on Mount Equinox, 1,500 feet above the village and 2,500 feet above the level of the sea and far from any habitation, is located the spring which supplies the Equinox mineral water. An analysis of this water in 1892 by Messrs. Chandler and Pellew, of New York, showed the following ingredients:

ONE UNITED STATES GALLON CONTAINS: Sodium bicarbonate, gr. 0.55; sodium chloride, gr. .48; potassium sulphate, gr. .08; calcium sulphate, gr. .15; calcium bicarbonate, gr. 1.98; magnesium bicarbonate, gr. .73; iron oxide and alumina, gr. .01; silica, gr. .18; organic and volatile matter, trace. Total solids, gr. 4.16.

This water has become well known for its purity and softness. It is widely used in the hotels, clubs, and private residences of many of our large cities as a drinking-water. It is very lightly mineralized, as shown by the analysis, yet it is recommended by numerous medical men as being useful in the treatment of gout, rheumatism, dyspepsia, and diseased conditions generally which are traceable to the uric-acid diathesis. *James K. Crook.*

END OF VOLUME III.